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WEEKLY March 23 - 29, 2024

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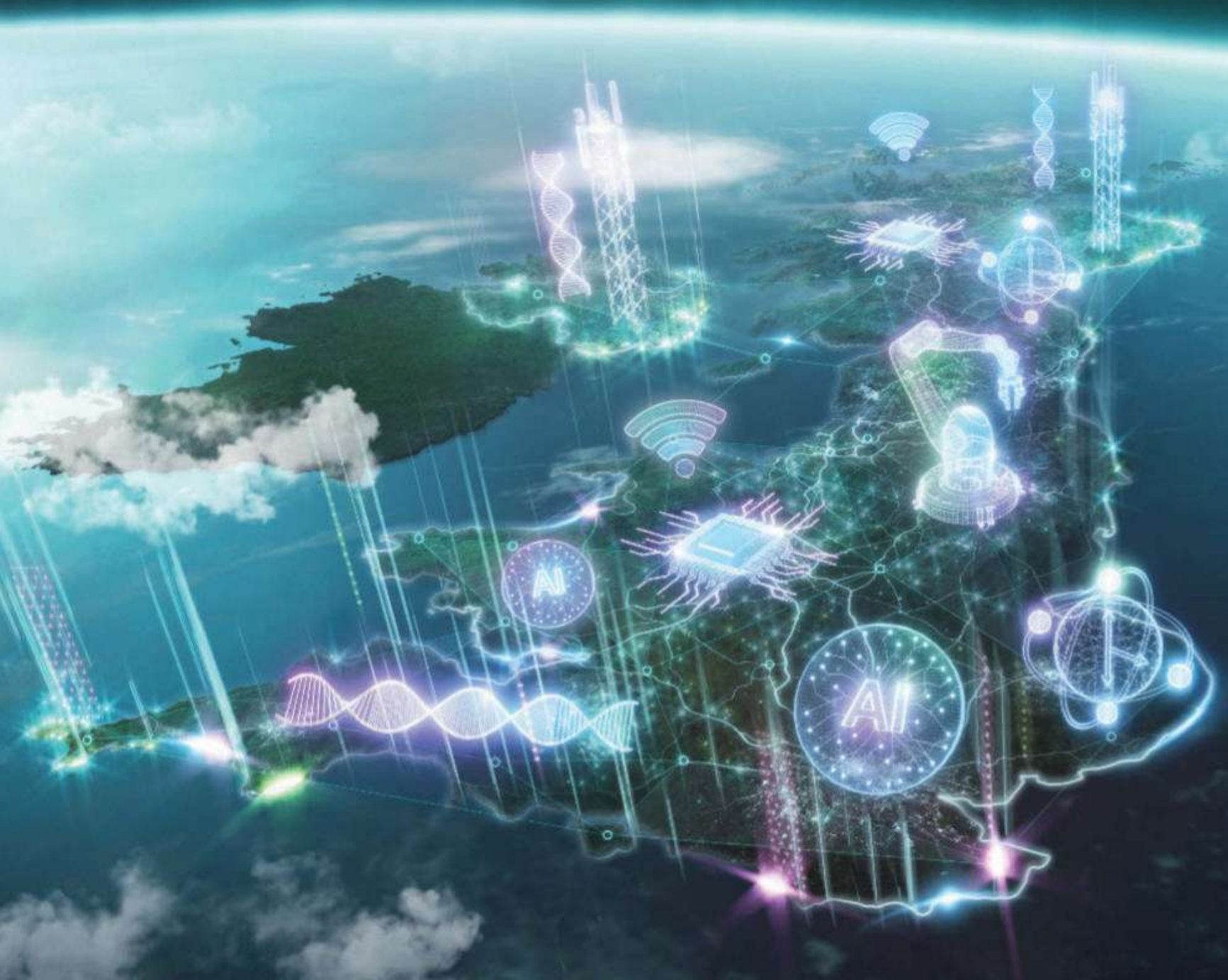

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Instant Expert

The future of medicine

Join six pioneering researchers who are creating new diagnostic tests and treatments to tackle some of society's most serious conditions, from Alzheimer's to diabetes, and even ageing itself. How is the latest medical research transformed into novel treatments? Find out during this one-day masterclass at London's Conway Hall on 18 May.

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Tour

The Rockies and the Badlands: Canada

Learn about the awe-inspiring geological processes that formed the Rocky mountains and Alberta Badlands. Expert palaeontologist and geologist Jon Noad will take you on a journey into deep time, from ancient life forms in coral reefs to dinosaur playgrounds and landscape-carving ice sheets. Plus, visit one of the world's most celebrated dinosaur museums. This seven-day tour starts on 17 June and costs £3999.

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Podcast

Weekly

The team consider that Mars may be able to tug on Earth's oceans despite its great distance from us. They also discuss how widespread hunger, disease and physical injuries caused by Israel's bombing and blockade of Gaza will have lifelong effects on survivors. Plus, hear why life on Europa may not be so likely and how giant redwood trees are living their best lives in Scotland.

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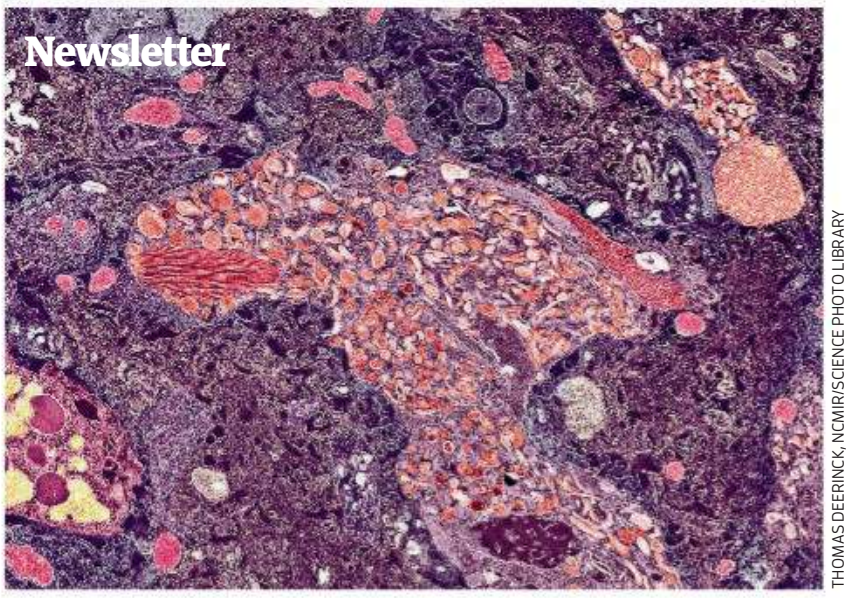

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Amyloid plaque Harmful proteins may not cause Alzheimer's

ARINDAM BHATTACHARYA/ALAMY

Top rocks The Rockies were uplifted over tens of millions of years

Video

Rewiring the mind

Ketamine is now the most common drug used in psychedelic therapy. Tristan Greene tells us about his experience of undergoing ketamine-assisted therapy for treatment-resistant depression and how it helped him to refigure the harmful mental ruts that he found himself in. "I was out of love with my mind," he says, but this therapy changed that.

youtube.com/newscientist

Newsletter

Health Check

New research suggests that fat globules accumulating in the brain cause Alzheimer's disease. Health reporter Clare Wilson asks whether Alzheimer's research up to now has been too focused on the build-up of a protein called beta-amyloid. And how can we marry these new ideas with the process of cognitive decline?

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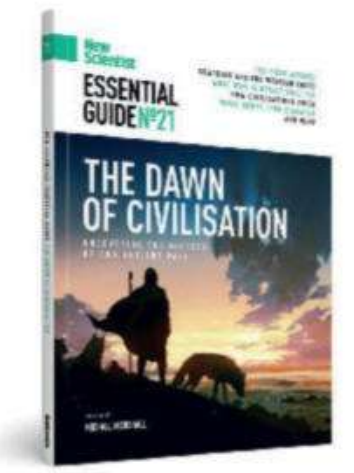
Podcast

"Giant redwood trees became a popular status symbol for wealthy Victorians"



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Spot the difference

Taking a philosophical view of the universe can help us distinguish fact from fiction

IT ISN'T easy to predict where the next leap in scientific understanding will come from. Indeed, ideas that, in hindsight, mark obvious paradigm shifts can first make you feel quite unsteady on your intellectual feet. So, as scientists poke around for new ways to understand the universe, how seriously should we take these embryonic revolutions?

In this week's cover feature (see page 32), philosopher Eric Schwitzgebel provides a handy guide to "weighing competing implausibilities". Much of his advice boils down to whether you prioritise conceptual simplicity over adherence to empiricism.

Take supersymmetry, the much-beloved (by physicists, at least) notion that every fundamental particle we know of has a much heavier partner that we are yet to discover. Its mathematical elegance sends proponents into rapture, but it is let down by the small matter of us not having a shred of evidence it is true.

Dark matter at first appears on firmer ground. Under our current best understanding of gravity, Albert Einstein's general theory of relativity, various lines of evidence point us towards the idea that 85 per cent of the mass within the universe is invisible. We see its gravitational effects throughout the cosmos. And yet, dark matter feels a bit too convenient. Yes, it explains a bunch of otherwise unexplainable phenomena, but given that we are yet to directly detect a particle of dark matter, that explanation feels uncomfortably like writing "here be dragons" in the margins of cosmology.

"Much comes down to whether you prioritise conceptual simplicity or empirical evidence"

That is why alternative approaches must be welcomed and judged on their relative merits, no matter how outlandish they may seem. As we report on page 10, a "post-quantum" theory of gravity is making waves by revisiting Einstein's assumptions about the nature of space and time. Crucially, it can explain a key observation without needing to invoke the existence of dark matter. Much work is needed, but judged using Schwitzgebel's tools, you may find this development is worth taking seriously, even if the current paradigm stands firm for now. ▮

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SPACEX

Space flight

Starship rocket reaches orbit

This is the atmospheric launch of SpaceX's Starship rocket on its third test flight. After lift-off from SpaceX's site at Boca Chica, Texas, on 14 March, Starship reached space, carried out fuel transfer tests and travelled further and faster than ever before. But it failed to make its scheduled landing and broke up on re-entry to Earth's atmosphere. The ultimate aim of the project is to put humans on the moon and, later, Mars.

Environment

Fears grow over Antarctic ice loss

Third year of low Antarctic sea ice cover raises worries an irreversible change has happened

James Dinneen

THE sea ice that encircles Antarctica has reached near-record low levels for the third year in a row, raising concerns that the ice has undergone a permanent "regime shift" driven by climate change. This could have alarming consequences for Antarctic ecosystems and the global climate.

Antarctic sea ice has long defied expectations. Modellers projecting its decline were flummoxed when sea ice cover there increased up to 2015, even as sea ice in the Arctic declined. Then, ice cover fell sharply below average the following year, reaching a record low early in 2017. That started to look like a trend as the ice set another record low in 2022, then again in early 2023 (see graph, below right).

Researchers were shocked when the ice failed to recover during the Antarctic winter last year, remaining so far below average that "our statistical models didn't work any more", says Edward Doddridge at the University of Tasmania in Australia.

In 2024, sea ice cover has again shrunk to a near record low (see map, below), reaching a minimum extent of just 1.99 million square kilometres on 20 February – the second lowest figure on record, according to the US National Snow and Ice Data Center. Now, all eyes are on winter sea ice, says Doddridge. "If 2024 is like last year, there's going to be a lot of evidence suggesting that Antarctic sea ice has changed, potentially irreversibly."

Whether the persistently low sea ice represents a permanent shift driven by climate change is unclear, says Catherine Walker at Woods Hole Oceanographic Institution in Massachusetts. "Is it a trend, or is it an elongated blip, or a regime shift?"

"Stopping the flow of cold water from Antarctica could have drastic effects on the climate"

One source of uncertainty is the short satellite record of Antarctic sea ice cover, which extends back only to 1979. That makes it hard to know the degree to which the fluctuation in sea ice is part of natural variability in the Antarctic or a response to climate change. Caroline Holmes at the British Antarctic Survey says the magnitude of the change suggests it is a combination of both.

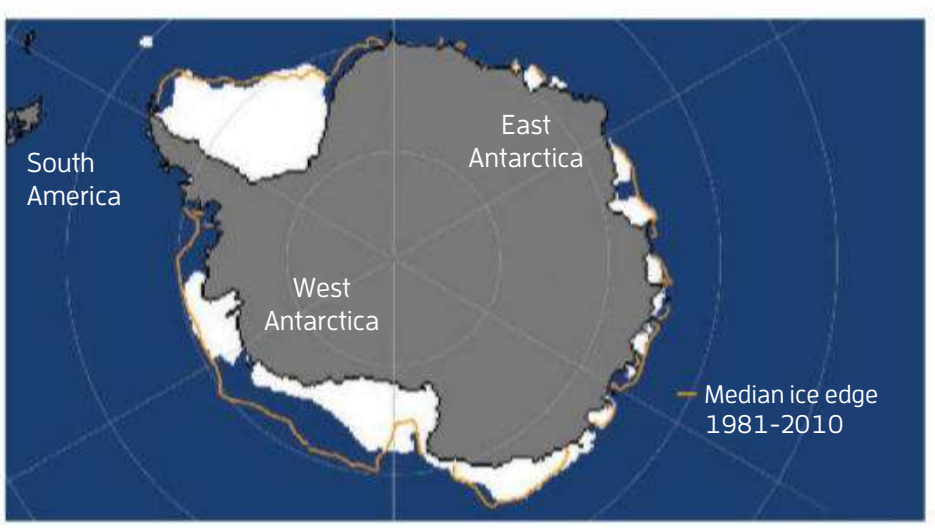
Researchers also aren't sure how the atmosphere and the ocean are driving sea ice changes, an essential part of understanding why those changes are happening. Extreme temperatures and changes in wind patterns did contribute to the startlingly low ice levels seen last winter, says Walker. But a recent study by Doddridge and his colleagues found these changes in the atmosphere aren't sufficient to explain the changes in sea ice over the past decade.

Changes in ocean temperature and salinity also drive variations in sea ice cover, but existing models can't resolve the complex interplay of these factors, says Zachary Kaufman at Stanford University in California. And there are other factors, such as rapid melting of large icebergs that normally anchor the sea ice.

The low level of sea ice cover may also have led to a warming feedback, because open water absorbs radiation that would normally be reflected by ice. This heat "memory" may persist for as long as three years in the Southern Ocean, compounding heat, according to results Doddridge

The area covered by Antarctic ice reached a record low in February

The area covered by sea ice in the Antarctic on 17 March, in white, was smaller than the 1981–2010 median ice extent for that day. The lowest ice extent for the Antarctic summer was seen on 20 February



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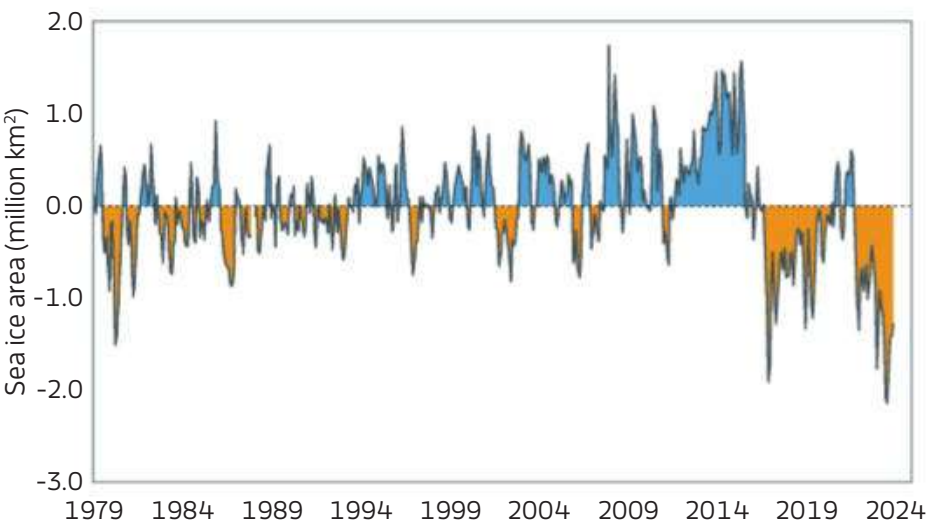
The area of Antarctic sea ice was generally above average between 1994 and 2015 (shown in blue) when compared with the 1979–2018 mean, but abruptly fell below average afterwards (orange)



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presented at the American Geophysical Union Ocean Science Meeting in Louisiana in February, where a possible regime shift was a key topic of discussion.

If the ice has shifted for good, the consequences could be large. Sea ice is an essential component of many Antarctic ecosystems, says Holmes. For instance, openings in sea ice provide nutrient-rich zones that support the entire food web, from plankton to big predators.

The loss of sea ice also means that the ice shelves extending out from the margins of the Antarctic ice sheet are more exposed to waves, leading to more melting, and subsequent sea level rise.

Shrinking sea ice could also have wider effects by altering the flow of cold water from Antarctica to the global ocean. Sea ice helps drive this circulation by generating dense water that sinks near Antarctica and adding fresh water when ice melts. "Slowing that circulation down or shutting it down could have drastic effects on the climate everywhere," says Walker. ▮

What do home test kits really reveal about our gut microbiome?

Many firms sell direct-to-consumer faecal testing kits, but it seems that they aren't supported by much evidence, says **Clare Wilson**

THE science of our gut microbiome is often painted as one of the hottest new areas of medicine, but there have also been claims that the research is overhyped. The latest aspect of this field to come under the spotlight is testing kits that let you send away a stool sample to learn if your gut bacteria could be affecting your health.

An analysis has found that claims about these kits aren't supported by evidence and the testing procedures aren't rigorous enough. Should companies even be allowed to sell them?

Microbiome research took off about 20 years ago, as advances in DNA sequencing let scientists find out more about the bacteria that live on and inside us.

Doctors have long known that some infectious conditions are caused by an overgrowth of pathogens. The revolutionary idea was that more subtle microbiome changes could cause conditions that are usually seen as having nothing to do with our gut, such as cancer and depression.

Despite the hype, the field hasn't yet transformed medicine. Faecal transplants – when stool from one person is transferred into another to boost their beneficial bacteria – have so far been licensed for just one rare medical condition, a severe form of diarrhoea that typically affects hospital patients who are taking strong antibiotics. And probiotic products – purported to deliver "good bacteria" to the gut – have generally not yet been shown to work in randomised trials, the gold standard of medical evidence.

But that hasn't stopped some firms from selling microbiome-related products to the public. This prompted the US National Institutes of Health to set up an investigation into the public's growing use of faecal testing kits.

Diane Hoffmann at the University of Maryland and her colleagues identified 31 companies around the world offering direct-to-consumer microbiome analysis kits. Based on the results of these analyses, users are given reports that may give a broad indication of their gut health, for instance in the form of a numerical score, or they may be told they have gut bacteria linked with a particular medical condition.

A big problem is that the science behind faecal DNA analysis isn't yet advanced enough to produce reliable conclusions, says Hoffmann. Previous research has shown that identical samples given to different laboratories can give varying results. This may be because of differences in how the sample is processed or which reference databases the firms use to judge someone's microbiome.

The companies generally don't give details about how they do their analyses, considering it commercially sensitive. "They're not required to give out the information," says Hoffmann.

A further issue is that even if we could accurately quantify how much of each bacterial species someone has in their faeces, there is no consensus among doctors about which bacteria are linked with specific medical conditions or a healthy gut, says Hoffmann. "They don't have the data necessary to say that someone's gut microbiome is healthy or unhealthy."

Analysis of stool samples can vary depending on which lab performs it

LEWIS HOUGHTON/SCIENCE PHOTO LIBRARY

"They don't have the data necessary to say that someone's gut microbiome is healthy"

Some of the firms selling these tests also have a conflict of interest. The team found that nearly half of the manufacturers sell supplements or probiotic products claimed to improve gut health, which they recommend to consumers based on their test results (*Science*, doi.org/mm2r).

The findings don't surprise Lesley Hoyles at Nottingham Trent University, UK, who co-authored a review of the field in *Nature Microbiology* last year, which concluded it was prone to "hype and misinformation". When it comes to faecal testing, "there's so much natural variation between individuals, it's meaningless", she says. "We don't know what a healthy microbiome is."

It might be tempting to think that if people want to waste their money on faecal test kits, they can. But many other direct-to-consumer medical tests, such as those for pregnancy or covid-19, are regulated by government agencies, which require good supporting evidence. It is time for microbiome tests to meet the same standards, says Hoffmann.

The microbiome field has great promise, but it is only in its infancy. For now, it may be wise to carry on just flushing our faeces down the toilet. ▮

Cosmology

Doing away with dark matter

Most physicists believe that only a quantum theory of gravity can fully explain the mysteries of the universe, but the idea of "post-quantum gravity" shows an alternative way, finds **Alex Wilkins**

A POTENTIAL new theory of gravity that ruffles the fabric of the universe, allowing space and time to vary erratically, could solve some of the largest mysteries in physics and do away with the need for dark matter, say its proponents. However, others say more evidence is needed before this "post-quantum gravity" can be taken seriously.

Most cosmologists believe that a substance called dark matter makes up about 85 per cent of the matter in the universe, despite it having never been seen directly after decades of searching. Instead, its presence has been inferred from astronomical observations, such as galaxies spinning faster than they should according to Albert Einstein's theory of gravity or tiny fluctuations in the cosmic microwave background (CMB) radiation that can't be explained by only the gravity of the matter we see in the universe.

Varying space-time

Now, Jonathan Oppenheim and Andrea Russo at University College London and their colleagues say that their new conception of gravity can explain the faster-than-expected rotation of galaxies without dark matter.

Many efforts to explain the universe focus on developing a theory of quantum gravity – unifying quantum mechanics and gravity, which currently break down when trying to understand extreme objects such as black holes. But Oppenheim takes a different approach. In his post-quantum gravity, everyday matter is still subject to the rules of quantum mechanics, but space-time remains non-quantum, or classical, while being allowed to vary randomly and ever so slightly as the universe evolves.

Oppenheim and a number of his colleagues have been working on this idea for some time, but now they have made two key breakthroughs. The first

"The calculations that have been done so far are encouraging, but there's a lot that can go wrong"

is to show that it works at all length scales, from the quantum to the cosmic, a test that any potential theory of gravity must pass (arXiv, doi.org/mm47).

Oppenheim and Russo have also calculated how gravity would act for very weak gravitational forces and over large scales, such as in the outer rotational arms of galaxies, by using mathematical machinery borrowed from quantum mechanics. They found that gravitational forces acting far from galactic centres would match what is inferred from observations of rotational speed at the outer edges of galaxies (arXiv, doi.org/mm46).

"This is the most promising new idea I've heard in some time," says Stacy McGaugh at Case Western Reserve University in Ohio. However, he says, many physicists might only consider its merits if they start seeing problems with the current model of the universe, which takes dark matter as real.

The idea could also work with another dark matter alternative called modified Newtonian dynamics (MOND). This tweaks the mathematics of Newtonian mechanics to reproduce phenomena like fast galaxy rotation, but doesn't suggest a physical explanation for this tweak. "This theory could provide the basis for MOND, and that's a really desirable thing," says McGaugh.

However, there are other observations that post-quantum gravity will need to reproduce before it is taken seriously by physicists, says Malcolm Fairbairn at King's College London, such as subtle fluctuations in the CMB radiation, which apparently provide a snapshot of how matter and dark matter were distributed in the universe's first moments.

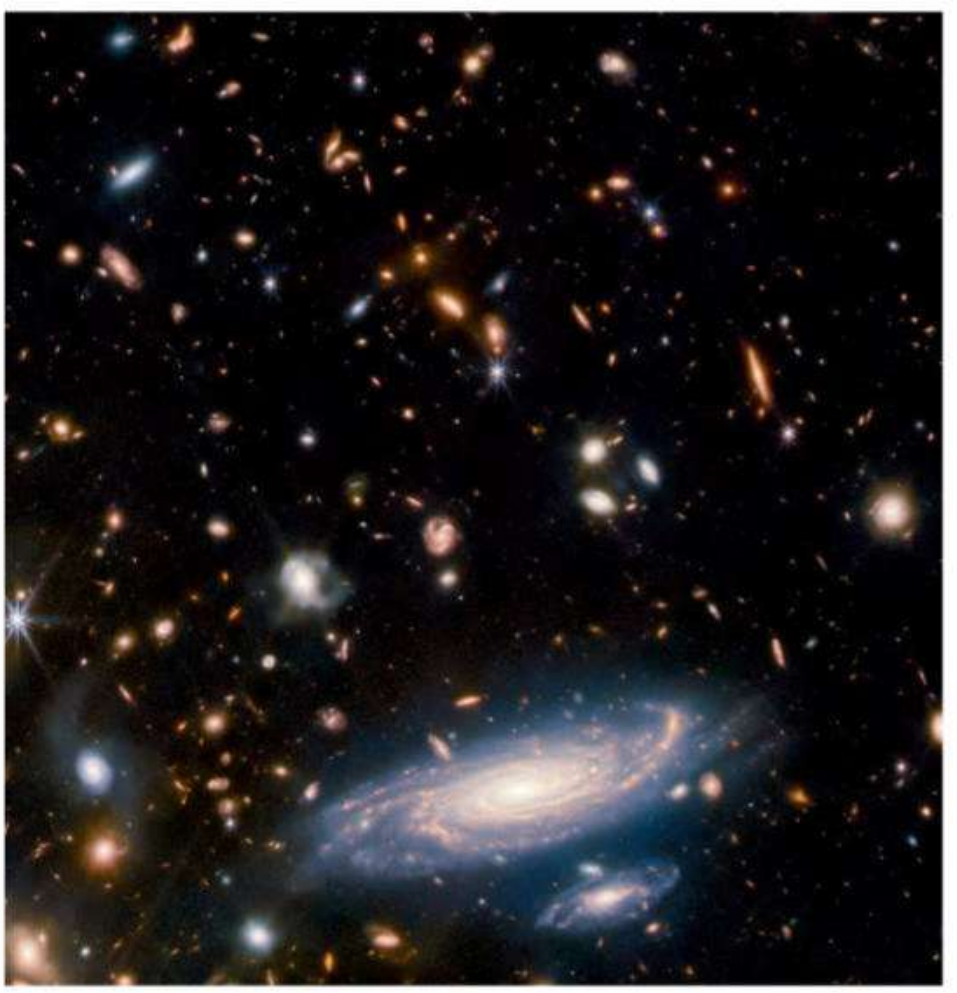
Not champagne time yet

There are some hints this could be possible, but "it's very, very early days", says Andrew Pontzen at UCL, who has worked on the idea with Oppenheim but wasn't involved in the recent research. "The calculations that have been done so far are encouraging, but they're very basic and there's a lot that can go wrong."

Along with the rotational speeds of galaxies and the CMB signals, Oppenheim and his colleagues will also need to show why galaxies within galaxy clusters move faster than they should according to how much mass we observe. "Until they can do those three things, it's not quite time to get the champagne," says Fairbairn.

Critics of post-quantum gravity remain unconvinced. In 2022, Oppenheim made a bet with physicist Carlo Rovelli on whether space-time is quantum or not, at odds of 5000:1. Rovelli says the new work hasn't changed his outlook.

Geoff Penington at the University of California, Berkeley, who also took part in the bet, says it is good that physicists explore many approaches to combining quantum mechanics with gravity, but "personally, I don't think this particular approach is likely to be the correct one". ▮



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Galaxies rotate faster than we expect, which is seen as evidence for dark matter

Climate change

Extreme heat could trigger the worst global financial crisis we have seen

James Woodford

WITHOUT dramatic action to curb carbon emissions, even high-latitude countries with cooler climates will suffer devastating financial losses as extreme heat disrupts global supply chains. The result could be the worst financial crisis the world has ever seen.

It is already well known that severe heatwaves have numerous health and economic impacts, including higher mortality rates, preventing people from working outside, destroying crops and disrupting industrial processes. But until now, little research has been done on the financial impact of heatwaves in exporting countries on importing ones.

Dabo Guan at Tsinghua University in Beijing, China, and his colleagues modelled the economic risks posed by three different climate scenarios, up to 2060. These involved a future in which the world shifts pervasively to a more sustainable path, a mid-range trajectory and a future where greenhouse gas emissions continue unabated.

In the low-emissions scenario, the team found a 25 per cent increase in heatwave days by 2060 compared with 2022 and 600,000 annual heatwave deaths, resulting in total global annual losses of $3.75 trillion, in 2020 prices. The highest-emissions scenario saw more than a 100 per cent increase in heatwave days and more than 1.1 million extra deaths per year by 2060, with total annual losses hitting $25 trillion (*Nature*, doi.org/mm2t). For comparison, global annual earnings in 2023 were around $100 trillion.

Wildfires in the Amazon are likely to cause knock-on effects elsewhere

DOUGLAS MAGNO/AFP VIA GETTY IMAGES

"No one can be immune from climate change, high-latitude countries will suffer from disruptions of international supply chains," says Guan, adding that climate events could have impacts that dwarf any previous financial crisis.

The team found that increasingly integrated global supply chains mean the impacts of heat stress aren't just confined to specific populations and industries in low latitudes, but extend more widely. In the high-emissions scenario, they found that losses from the indirect effects on global supply chains grow exponentially from 2030, and by 2060 become the major contributor to total losses. This highlights the exposure that even cool climate nations face.

For example, the UK is unlikely to be severely affected directly by temperatures seen at lower latitudes, but severe heat impacts on wheat and coffee bean suppliers in Africa and South America could see drastic falls in supplies of beer or coffee in the UK.

These kinds of spillover effects have consequences for global food security, energy and mineral supply, even if wealthier nations can mitigate the direct effects of extreme heat with technology such as air conditioning.

If we continue on a high-emissions scenario, there will be severe consequences, says Guan. "People will suffer from disruption of electricity, shortage of food or price surges and loss of employment." ▮

Technology

Nvidia's Blackwell AI 'superchip' is the most powerful yet

US COMPUTING firm Nvidia has unveiled a "superchip" for training artificial intelligence models, the most powerful it has ever produced.

The chip was announced by Nvidia CEO Jensen Huang at a press conference in San Jose, California, on 18 March. He showed off the company's new Blackwell B200 graphics processing units (GPUs), each of which has 208 billion transistors – the tiny switches at the heart of modern computing devices – compared with the 80 billion transistors of Nvidia's current-generation Hopper chips. He also revealed the GB200 Grace Blackwell Superchip, which combines two of the B200 chips.

"Blackwell is just going to be an amazing system for generative AI," said Huang. "And in the future, data centres are going to be thought of as AI factories."

GPUs have become coveted hardware for any organisation seeking to train large AI models. During AI chip shortages in 2023, Elon Musk spoke of GPUs being "harder to get than drugs".

Nvidia claims its Blackwell chips can deliver 30 times performance improvement when running generative AI services based on large language models such as OpenAI's GPT-4 compared with Hopper GPUs, all while using 25 times less energy.

It says that whereas GPT-4 required about 8000 Hopper GPUs and 15 megawatts of power to perform 90 days of training, the same AI training could be done using just 2000 Blackwell GPUs consuming 4 megawatts of power.

"In the future, data centres are going to be thought of as AI factories"

The company hasn't yet revealed the cost of the Blackwell GPUs, but it is likely to be eye-watering, given that the Hopper GPUs cost between $20,000 and $40,000 each.

This focus on more powerful and expensive chips means they "will only be accessible to a select few organisations and countries", says Sasha Luccioni at Hugging Face, a company that develops tools for sharing AI code and datasets. ▮

Jeremy Hsu

Health

Intermittent fasting linked to a higher risk of heart disease death

Clarissa Brincat

RESTRICTING your eating window to just 8 hours a day – a popular type of intermittent fasting – has been linked to a higher risk of dying from heart disease. But some scientists argue that this may be because people with pre-existing health conditions unknowingly opt for intermittent fasting and that what we eat is probably more important than when we eat.

Time-restricted eating has previously been associated with improved blood pressure, blood glucose and cholesterol levels, but its long-term effects are unclear. To learn more, Wenze Zhong at the Shanghai Jiao Tong University in China and his colleagues studied about 20,000 adults, roughly half men and half women, who took part in the US National Health and Nutrition Examination Survey. Their average age was 49 and just under three-quarters were non-Hispanic white people.

Every year from 2003 to 2018, the survey's participants self-reported dietary information. The researchers matched this against death records between 2003 to 2019. Participants were only included if they were aged 20 or older and had completed two diet questionnaires in their first year of the survey.

Over an average follow-up period of eight years, the researchers found that those who ate during an 8-hour daily window didn't live longer than those with a more traditional eating schedule of 12 to 16 hours, despite intermittent fasting often being lauded for its benefits to longevity.

The researchers also found that people who followed an 8-hour eating schedule were 91 per cent more likely to die from heart disease in the follow-up period than those who ate over 12 to 16 hours.

MORSA IMAGES/GETTY IMAGES

Eating in an 8-hour window, also known as the 16:8 diet, is a popular form of fasting

For people diagnosed with heart conditions before the study, eating during an 8 to 10-hour window was linked to a 66 per cent higher risk of death from heart disease than it was for those who ate over 12 to 16 hours. Among people diagnosed with cancer, eating over a window of more than 16 hours was associated with a lower risk of death from the condition than a more constricted eating schedule.

91%

Higher risk of death from heart disease for people on 16:8 diet

The study – presented this week at the American Heart Association (AHA) Epidemiology and Prevention conference in Chicago – doesn't prove that time-restricted eating caused any of these deaths, says Zhong.

It is important to consider the reasons for the participants' time-restricted eating, says Benjamin Horne at the Intermountain Heart Institute in Salt Lake City, Utah. Some might have done it deliberately, while others may have had limited eating windows due to health conditions or treatments affecting their appetite, he says.

Some may have also had a restricted eating schedule because of limited access to food, says Jo Ann Carson, former chair of the AHA nutrition committee. Research suggests that food insecurity is associated with unhealthy lifestyles that lead to heart disease. We also don't know how healthy the foods people ate were, says Carson.

People who want to reduce their likelihood of dying prematurely "should aim for an overall heart-healthy dietary pattern, regardless of the time of day they eat", says Carson. Those who wish to start intermittent fasting should speak to their doctor beforehand, says Horne. ▮

Archaeology

Humans and sabre-toothed cats shared a mammoth meal

Jeanne Timmons

A MAMMOTH that died about 1.2 million years ago became a feast for both ancient humans and sabre-toothed cats, an analysis of its bones has revealed.

The fossil skeleton of this southern mammoth (*Mammuthus meridionalis*) was excavated about 20 years ago at a site in Orce, Spain. These animals were larger than today's elephants and roamed Eurasia during the Pleistocene. The site also features stone tools, suggesting the presence of an early human species, such as *Homo erectus*.

A previous study dismissed the skeleton as having no marks made by tools or animal bites, but now José Yravedra at Complutense University of Madrid in Spain and his team have re-examined it. They found marks on the ribs and pelvic bones that may be from stone tools or sabre-toothed cats.

To determine what caused the marks, the team recreated flint and limestone tools matching those found at the site and used them to butcher pig limbs. After using scanners to build a 3D model of the new and ancient cut marks, they trained an artificial intelligence to distinguish between cut marks and tooth marks, says Yravedra.

The results suggest that both humans and cats scavenged the meatiest parts of the carcass, but it isn't clear which species got there first or whether either killed the mammoth. The team notes that the type of tools found at the site wouldn't have been strong enough to kill an animal that large and sabre-toothed cats would only have attacked an adult mammoth if it were sick or dying. The age of this mammoth at death suggests it may have died naturally (*Quaternary Science Reviews*, doi.org/mm4v).

The carcass would have weighed 3 tonnes, so would have provided enough food for both species. ▮

Mathematics

A new take on Fermat's last theorem

Mathematicians plan to translate the infamous problem into a machine-readable version

Alex Wilkins

THERE is a plan afoot to develop a computerised proof of Fermat's last theorem, an infamous statement that has beguiled mathematicians for centuries, in an ambitious project that aims to demonstrate the potential of computer-assisted mathematical proofs.

Pierre de Fermat's theorem, which he proposed in around 1640, states that there are no integers, or whole numbers, a, b and c that satisfy the equation $a^n + b^n = c^n$ for any integer n greater than 2. Fermat scribbled the claim in a book, famously writing: "I have discovered a truly marvellous proof of this, which this margin is too narrow to contain."

It wasn't until 1993 that Andrew Wiles, then at Princeton University, set the mathematical world alight by announcing he had a proof. Spanning more than 100 pages, it contained such advanced mathematics that it took more than two years for his colleagues to verify it.

Many mathematicians hope that this work of checking – and eventually writing – proofs can be sped up by translating them into a computer-readable language. This process, called formalisation, would let computers instantly spot mistakes and, potentially, use the theorems as building blocks for other proofs.

But formalising modern proofs can itself be tricky and time-consuming, because much of the modern maths involved is yet to be made machine-readable. For this reason, formalising Fermat's last theorem has been considered out of reach. "It was regarded as a tremendously ambitious proof just to prove it in the first place," says Lawrence Paulson at the University of Cambridge.

"There's no point in Fermat's last theorem. But it's also a really hard question"

Now, Kevin Buzzard at Imperial College London and his colleagues have announced they will attempt to formalise Fermat's last theorem in a programming language called Lean.

"There's no point in Fermat's last theorem, it's completely pointless. It doesn't have any applications – either theoretical or practical – in the real world," says Buzzard. "But it's also a really hard question that's become infamous because, for centuries, people have generated loads of brilliant new ideas in an attempt to solve it."

He hopes that by formalising many of these ideas, which now include routine mathematical tools in number theory such as modular forms and Galois representations, it will help other researchers whose work is currently too far beyond the scope of computer assistants.

"It's the kind of project that could have quite far-reaching and unexpected benefits," says Chris Williams at the University of Nottingham, UK.

The proof itself will loosely follow Wiles's one. A publicly available blueprint will be put online once the project is live, in April, so anyone from Lean's community can help formalise sections of the proof.

"Ten years ago, this would have taken an infinite amount of time," says Buzzard. Even so, he will be concentrating on the project full-time from October, putting his teaching responsibilities on hold for five years.

GRANGER/ALAMY

Pierre de Fermat's scribblings set mathematicians on a centuries-long quest

"I think it's unlikely he'll be able to formalise the entire proof in the next five years, that would be a staggering achievement," says Williams. "But because a lot of the tools that go into it are so ubiquitous now in number theory and arithmetic geometry, I'd expect any substantial progress towards it would be very useful." ▮

Technology

Buildings could be 3D printed using ink made of waste wood

RECYCLED wood can be turned into an ink for 3D printing, which could offer a more sustainable way to make furniture or build houses.

"Wood has been used for building and structural purposes for centuries," says Muhammad Rahman at Rice University in Texas. But using it isn't especially efficient, because cutting wood down to size can result in lots of waste.

To make use of this leftover material, Rahman and his colleagues split it into lignin and cellulose – molecules that are key to the stiff structure of wood – and broke these down to form nanofibres and nanocrystals. They then recombined the cellulose and lignin with water to make a clay-like substance that could be used as an ink (*Science Advances*, doi.org/mm2s).

The researchers used this substance for 3D printing by forcing it through a nozzle and building up layers of ink.

To boost the strength of the 3D-printed objects, the team freeze-dried them to remove moisture and then heated them up to 180°C (356°F) to make the lignin soften and fuse with the cellulose.

"We can actually mimic all the visual, textural and olfactory properties of natural wood," says Rahman. The product was found to be nearly six times as durable as natural balsa wood in compression tests and up to three times as flexible in bending tests.

THAKUR ET AL., SCI. ADV. 10, EADK3250 (2024)

A miniature chair and table 3D printed from waste wood

So far, the researchers have managed to create miniature furniture and honeycomb structures using the ink, but they hope it could eventually be used to build larger objects, such as houses.

"We need to rethink how we can make structures without cutting down trees," says Rahman. "If we can recycle waste wood using 3D printing instead of conventional manufacturing, that would be a good step forward." ▮

Chen Ly

Analysis Climate-friendly food

Should we eat snakes to save the planet?

Pythons convert food into meat more efficiently than other livestock and can be fed on waste meat, but this doesn't mean eating snakes is inherently more sustainable, says **Michael Le Page**

WHAT kind of meat is the most sustainable? According to a study of snake farms in Thailand and Vietnam, it might be pythons.

When it comes to the efficiency of converting food into meat, pythons come out top, says Daniel Natusch at consulting firm EPIC Biodiversity. "No other livestock species studied to date possesses the same credentials or rates of production as pythons."

Some snakes have long been farmed on a small scale for products such as venom. Only recently have they begun to be raised mainly for meat. Natusch's team measured the growth of nearly 5000 reticulated and Burmese pythons (*Malayopython reticulatus* and *Python bivittatus*) over a year, along with what they were fed, plus the weight of their dressed carcasses – that is minus the skin, internal organs, head and tail.

According to the study, the dry mass of the food the pythons were fed was 1.2 times that of the dressed carcass, compared with 1.5 for salmon, 2.1 for crickets, 2.8 for poultry, 6 for pigs and 10 for beef.

The dry mass of the protein fed to the snakes was 2.4 times that in a dressed carcass, compared with 3 for salmon, 10 for crickets, 21 for poultry, 38 for pigs and 83 for beef (*Scientific Reports*, doi.org/mm2h).

Calculating how much food is converted into meat is tricky, says Kajsa Resare Sahlin at the Stockholm Resilience Centre in Sweden. It is also important to take account of what protein animals are eating and where it comes from, she says.

A key thing missing from the comparison is that snakes eat animals that ate plants, but other farm animals eat mostly plants. If the total mass of plant material required per kilogram of carcass were compared, snakes might not look so efficient.

Workers feeding Burmese pythons on a farm in Vietnam

DAN NATUSCH

Asked about this, Natusch says that what makes snake meat sustainable isn't the efficiency of food conversion, but the fact they are fed on waste meat, such as from trapped rodents and stillborn pigs.

"Livestock fed on plant protein sourced from a crop monoculture where a natural habitat once stood... is far less sustainable than capturing rodent pests or using waste protein to feed pythons," says Natusch.

For this reason, he thinks snake meat is more sustainable than many plant-based foods.

If the snakes are being fed waste, this would be an efficient use of resources, says Resare Sahlin. But rodents could refer to many species. "If these are rats, then in the short term it could be beneficial to use them, but if a whole industry develops around this as a feed source, it will create perverse incentives to maintain 'rat problems'," she says. So even though snake meat as it is now produced might be more sustainable than many other types of meat, this study doesn't show it is inherently more sustainable, she says.

Natusch makes two other arguments for snake farming. The first is food security. Many of the snakes chose to go for periods of up to 127 days without eating, yet lost just a few percentage points of body mass. This means farmers can stop feeding them for weeks or months if there are global shocks that interrupt supply chains, says Natusch.

Second, Natusch thinks farming snakes is more ethical than farming birds or mammals. Pythons don't have the same cognitive capacity and choose to remain inactive in small confined spaces when they don't need food, he says.

As for what python meat is like, it tastes like chicken, says Natusch. "I've had it in curries, BBQ, as satay skewers and as biltong. If prepared well, it's great." ▮

Technology

Gold flecks create a new kind of one-way window

GLARE-free windows could be made from a material studded with billions of tiny metal patches. This makes a matte one-way window that reflects almost no light from outside, and would allow people inside to have privacy without blurring their view.

Yun Lai at Nanjing University in China and his colleagues have created a glass-like material called a transparent matter surface (TMS), which has a similar matte finish to frosted glass.

Lai says that being matte and transparent are typically mutually exclusive properties. To achieve both, the researchers covered a wafer of the material in billions of nano-sized patches that scatter and reflect light. They made these from a reflective metal, such as gold, and materials like silicon that conduct electricity poorly, which reduces how much light they reflect.

The TMS reflected as little as 1.3 per cent of light shone onto it, but emitted enough light that a camera with the material placed over its lens could still take clear photographs. The researchers also tested the TMS on a camera connected to an AI that identifies and labels objects. The AI could sucessfully identify a tennis ball on the other side of the TMS (*Science Advances*, doi.org/mm2d).

"Being matte and transparent are typically mutually exclusive properties"

The moment they first saw the sample was fascinating, says Lai. "It was difficult to imagine how a material could be clear and undistorted when light passes through it but also have a hazy appearance when reflecting light."

Simon Horsley at the University of Exeter, UK, says this material could produce "quite large windows" and may help cut light pollution from reflected light. ▮

Karmela Padavic-Callaghan

Ageing

How mental health conditions seem to make you age faster

Grace Wade

PEOPLE with a mental health condition have more RNA damage than those without one. Since RNA damage accelerates ageing, these findings could explain why mental illness is linked to an increased risk of dying from age-related diseases such as cancer or type 2 diabetes.

Anders Jørgensen at Frederiksberg Hospital in Denmark and his colleagues measured markers of damaged RNA and DNA in more than 7700 people aged 25 and up, almost 3100 of whom had a history of mental health conditions. They focused on markers of oxidative stress, which occurs when reactive compounds containing oxygen damage cells. Oxidative stress contributes to age-related conditions like heart disease, dementia and cancer. Sources of the compounds that cause oxidative stress include digestion, smoking and pollution.

Urine samples collected between 2007 and 2013 from people with a mental health condition had levels of a particular marker of RNA damage that were 9 per cent higher, on average, than those of samples from people without a mental health condition, after taking into account the age of the participants.

By tracking participant deaths from the time each joined the study until the end of May 2023, the team found participants with high levels of the marker and a mental health condition were almost twice as likely to die as those with low levels and no mental health condition (*JAMA Psychiatry*, doi.org/mmz6).

The findings suggest that RNA damage from oxidative stress may explain the association between mental illness and premature death. Why people with psychiatric conditions have more oxidative stress is unclear, says Jørgensen. It may be because smoking or obesity is seen more often in people with mental health conditions, he says. ▮

Planetary science

Blow dealt to hopes that Europa's ocean hosts life

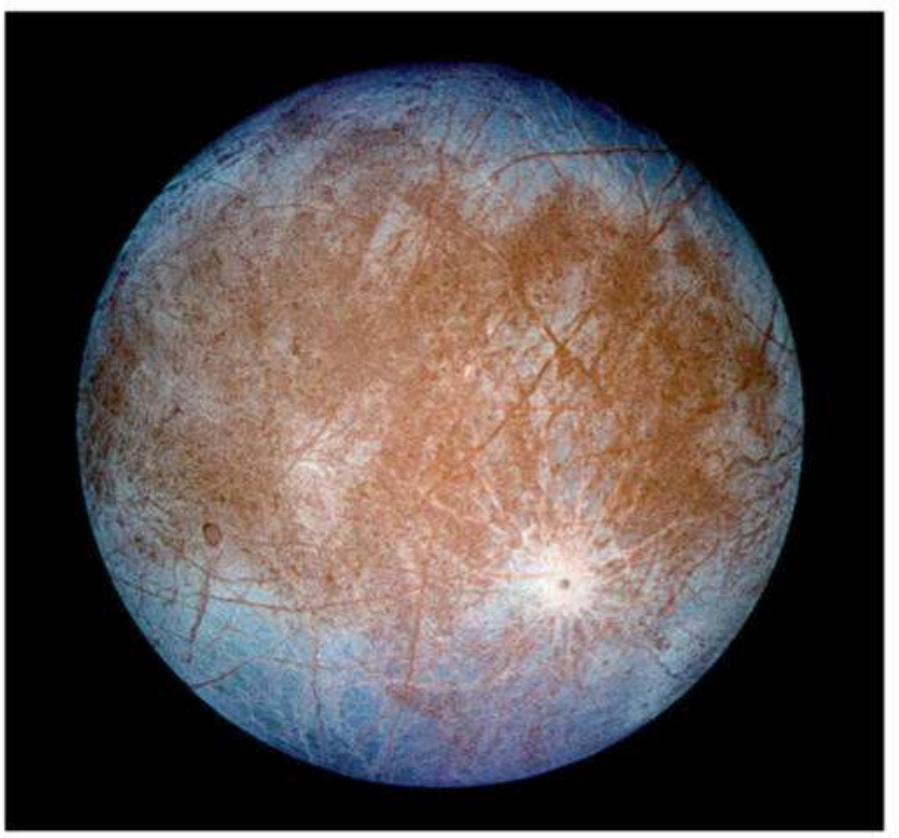
Leah Crane

JUPITER'S icy moon Europa may not be as ripe for life as we thought. Its underground ocean has long made it one of the most promising candidates in our solar system to host life, but theoretical studies of its seafloor are putting a damper on its promise.

On Earth, much of the life in the deep ocean is supported by hydrothermal activity at the seafloor, where water interacts with rock. This provides nutrients and energy for living organisms, and researchers think that similar processes could aid life on Europa.

However, these interactions require a regular supply of fresh rock. That can come from faults in the rock or via volcanic activity that lets magma rise from deep underground. Research discussed at the Lunar and Planetary Science Conference in Texas on 11 and 12 March suggests both things may be unlikely on Europa.

Europa, a moon of Jupiter, has an underground ocean



NASA/JPL/DLR

"There's been a lot of work done on the outer shell because we can see it… but we don't have much information on the seafloor, not surprisingly, because it's extremely hard to get to," said Paul Byrne at Washington University in St. Louis, Missouri. Studies of Europa's seafloor have had to rely on theoretical calculations, simulations and comparisons to what we see on Earth.

The most dramatic way Europa's core could contribute to the habitability of its ocean is via volcanism – magma from deep underground seeping into the ocean through cracks called dikes. Austin Green at NASA's Jet Propulsion Laboratory in California and his colleagues simulated this process, but the dikes weren't able to transport magma all the way from the molten areas deep in the core to its edge.

"They did really, really, really, really bad," said Green. "Our most successful one was an 11.5-kilometre dike." That one would have had to penetrate 227 kilometres of rock to spill magma onto the seafloor. "If this volcanism is necessary for habitability, Europa's ocean is uninhabitable," said Green.

> **"If this volcanism is necessary for habitability, Europa's ocean is uninhabitable"**

The faults in the seafloor don't necessarily have to have magma in them to be useful, though. Even empty faults could fuel important water-rock interactions – but Byrne and his team found that it is unlikely that any new faults are forming under Europa's sea. "I don't think there's anything happening at the ocean floor," said Byrne.

Another research group found that even simple erosion by sand is unlikely because the moon's low gravity means that the sediment should sit lightly on the seafloor, not providing enough weight to wear it down. "Unfortunately, I'm kind of adding to the depressing news that maybe the seafloor isn't as active as we maybe thought it could be," said team member Perianne Johnson at the University of Texas at Austin.

This doesn't mean Europa is uninhabitable, though. "I think that what's being shown here is that volcanism and habitability models that rely on the interior are starting to be less likely, but I still think that stuff coming through the ice shell from the top down is still a pretty promising avenue of research," said Green. ▮

Biotechnology

Plant-killing genetic technology could wipe out superweeds

Michael Le Page

A GENE drive – a bit of DNA that cheats evolution and can spread even if harmful – has been successfully tested in a plant for the first time. The approach could be used to wipe out invasive plants and superweeds without harming other species, cutting herbicide use.

Gene drives work by skewing the odds of an organism inheriting a piece of DNA. Most plants and animals have two copies of each gene, meaning there is usually a 50 per cent chance of a particular copy being passed on to offspring. A gene drive could raise that chance to, say, 80 per cent, allowing the genes to spread even if they are detrimental.

There are many natural gene drives that work via a variety of mechanisms. And in 2013, the first artificial gene drive was created using the CRISPR gene-editing technique.

It copies itself from one chromosome to the other, so all offspring inherit it. This method is called a homing gene drive, because the drive copies itself to a specific site.

Bruce Hay at the California Institute of Technology and his colleagues have taken a different approach, called cleave and rescue. Their gene drive consists of CRISPR elements that target and destroy both copies of a key gene needed for pollen and eggs to form. However, the drive also contains a working version of this gene that doesn't get destroyed.

Pollen and eggs that don't inherit the gene drive lack the key gene, so don't develop. Only pollen and eggs with the gene drive develop normally, so all offspring inherit it.

The cleave-and-rescue approach should work in all

BILL BARKSDALE/AGSTOCK/DESIGN PICS INC/ALAMY

Palmer's pigweed sending flower shoots up above soya bean plants

animals as well as plants, says Hay, and could be used to eliminate rats from islands where they are wiping out native species.

Hay's team has tested a version of this drive – designed only to spread, not to kill – in the thale cress *Arabidopsis thaliana* (bioRxiv, doi.org/mmkr).

The researchers now plan to test the drive in Palmer's pigweed (*Amaranthus palmeri*), a herbicide-resistant superweed that is a problem for farmers in many parts of the world.

What's more, the technology could be adapted to control weeds without spreading indefinitely. For instance, it could be used to create male plants with pollen that kills off any female offspring. Planting these male plants around farms each year would eliminate that weed species from the fields after a few years by blocking seed production.

"That would ultimately crash the entire local population… just by eliminating females," says Hay. However, the female-killing trait would die out if no more male plants with it were planted.

This approach is more likely to be approved by regulators than a gene drive that keeps spreading until resistance evolves, says Hay. A similar

"Gene drives could create male plants with pollen that kills any female offspring"

approach is already being used by a firm called Oxitec to control malaria-carrying mosquitoes.

Paul Neve at the University of Copenhagen in Denmark thinks the chances of getting approval to release gene drives for agriculture are slim. Another problem is that plants usually produce seeds once per year and it can take 10 generations for drives to spread widely, he says. "How do you get a gene drive to spread fast enough to deliver meaningful weed control?" ▮

Solar system

A single meteorite created a billion craters on Mars

Leah Crane

WHEN a single meteorite struck Mars a few million years ago, it didn't just create one crater – it ultimately made billions of them.

A meteorite slamming into the ground can blast a huge plume of rocks into the air. When the rocks fall back down, they create their own smaller craters, often in chains and clusters around the original impact site. This process is common on rocky bodies with thin atmospheres like Mars or the moon, but is harder to spot on Earth, where geological activity can destroy the evidence.

Matthew Golombek at NASA's Jet Propulsion Laboratory in California and his colleagues used images from two spacecraft orbiting Mars to estimate the number of secondary craters created by the debris from the Corinto crater, which formed about 2.3 million years ago and is just under 14 kilometres across. They found that Corinto has between 1.3 billion and 3 billion secondaries – the most ever spotted on Mars. Each secondary was at least 10 metres across. Golombek presented this work at the Lunar and Planetary Science Conference in Texas on 11 March.

The craters cover an area of about 1.4 million square kilometres, including the area where NASA's Mars InSight spacecraft landed in 2018. The area is volcanic, and the craters pepper the surfaces of dried lava flows from Elysium Mons, one of the tallest mountains on Mars.

"Quantifying the number of secondaries is important to better understand how a relatively small crater could possibly eject that much material during the cratering process," says Golombek. The formation of secondaries depends on the geology of the area, as well as the properties of the impactor itself, so studying them could help us understand what Mars is made of and how various materials react to space rocks slamming into them. ▮

Health

Brain fat linked to Alzheimer's

Genetic risk factor for disease seems to lead to build-up of fat droplets in some cells

Clare Wilson

A NEW understanding of Alzheimer's disease suggests that the root cause involves a build-up of fat droplets in brain cells.

Tackling these droplets could lead to more effective treatments than the current strategy of drugs that target proteins, says Michael Haney at the University of Pennsylvania. "This opens up a new avenue for therapeutic development," he says.

The commonest explanation for this type of dementia is that it is caused by the aggregation of a protein called beta-amyloid to form plaques between nerve cells. Another suspect is a build-up of tangles made of a different protein, called tau, in nerve cells.

The amyloid hypothesis is favoured because some antibody treatments that rid the brain of it have recently shown modest effectiveness at slowing memory loss in people with Alzheimer's.

But the debate between these two possible culprits ignores the fact that fat droplets can also be

JUAN GAERTNER/SPL/ALAMY

Clumps of misfolded beta-amyloid peptides (orange) in Alzheimer's disease may spark fat accumulation

seen in the brains of people who have died with the condition, says Haney. These were first described by Alois Alzheimer, a German doctor who gave his name to the condition in the early 20th century, when he saw amyloid plaques, tau tangles and fat droplets in the brains of people who had Alzheimer's. For decades, the fat was mostly overlooked.

In the latest study, Haney was investigating the biggest genetic risk factor for Alzheimer's disease: a gene called *APOE*. The protein it encodes helps transport fat into and out of cells.

People have different variants of this gene, called *APOE2*, *3* and *4*. Of these, *APOE2* brings the least risk of developing Alzheimer's, while *APOE4* brings the most, but until now, it wasn't clear why.

To shed more light on this, while he was working at Stanford University in California, Haney and his colleagues used a method called single-cell RNA sequencing to identify which proteins were made in individual cells. They did this for tissue samples from people who had died from Alzheimer's disease, who had either two copies of the *APOE4* variant or two copies of *APOE3*.

This showed that people with *APOE4* had higher levels of a certain enzyme in immune cells in their brain, the effect of which was to boost fat droplets in those cells.

Next, the team grew these brain immune cells – called microglia – in a dish, using cells from living people with either the *APOE4* or *APOE3* variant. Applying amyloid to the cells made them accumulate fat, especially if they had the *APOE4* variant (*Nature Medicine*, doi.org/gtmssj).

The team concludes that in Alzheimer's, a build-up of amyloid triggers fat accumulation. This then leads to the build-up of tau inside neurons, which causes cell death, and so leads to memory loss and confusion.

Previous studies have found that other genes that raise Alzheimer's risk tend to be involved in fat metabolism

"Targeting fat droplets opens up a new avenue for therapeutic development for Alzheimer's disease"

or the immune system, which further supports the latest hypothesis, says Haney.

Irundika Dias at Aston University in Birmingham, UK, says previous studies have suggested that fat metabolism in other kinds of brain cell could also be playing a role. "The common thing tying all these [findings] is involvement of lipid [fat] metabolism," she says. ▮

Animal behaviour

Chimp mothers play with their young even in tough times

WHEN there isn't much food to go around, most chimps stop playing to conserve energy, but mothers continue to frolic with their babies.

Great apes such as gorillas, bonobos and chimpanzees all have a penchant for playing, which includes tickling, poking and chasing each other. "Play helps to develop both motor and social skills," says Zarin Machanda at Tufts University in Massachusetts. "It is something that babies really need to do in order to develop properly."

Machanda and her colleagues recorded 3891 bouts of play in a community of about 60 eastern chimpanzees (*Pan troglodytes schweinfurthii*) in Kibale National Park in Uganda, between 2010 and 2019.

"In 2016 or 2017, we had this incredible summer where there was just food everywhere at our field site," says Machanda. "One of the things that we noticed was lots of adult chimps playing with each other."

In times of abundance, the team recorded at least one instance of play on 97 per cent of observation days, but this dropped to 38 per cent when food was scarce.

Mother chimps, however, kept playing with their children at even

DR. KRIS SABBI

Young Ginger climbs on her mother in Kibale National Park

higher rates during these low food availability periods (*Current Biology*, doi.org/mmfc). "That was really surprising," says team member Kris Sabbi at Harvard University, as food is generally more important to female chimps because of the high energetic cost of reproduction.

During periods of food stress, chimps tend to spend more time alone to avoid competition for resources, which means mothers often become the only social partner for their babies. As a result, mothers spend even more time playing with their children to make up for the lack of socialising.

"The fact that moms are continuing to play with their babies at a cost to themselves indicates how important it is for their development," says Machanda. ▮

Chen Ly

Environment

US methane leaks are triple the official estimates

James Dinneen

MAJOR oil and gas-producing regions in the US are leaking much more methane than current estimates suggest, according to nearly a million aerial measurements of the potent greenhouse gas.

"Our study used the largest such dataset that's ever been assembled," says Evan Sherwin at Lawrence Berkeley National Laboratory, who conducted the research while at Stanford University, both in California.

He and his colleagues combined data from numerous aerial surveys that used infrared sensors to measure methane leaking from wells, pipelines and other infrastructure in the oil and gas-producing regions of the US. Together, these surveys covered 52 per cent of all US onshore oil production and 29 per cent of natural gas production.

To estimate methane emissions too diffuse to be detected from the air, the researchers also extrapolated from a few ground-based measurements to simulate total emissions.

On average across the regions surveyed, they found methane leaking at a rate of 2.95 per cent of total natural gas production, a number nearly three times what the US Environmental Protection Agency estimates (*Nature*, doi.org/mmdg).

It is also about 50 per cent greater than the current best estimates based on more limited measurements, says Sherwin.

The estimated 6.2 million tonnes of annual methane emissions from these sites represent about $1 billion in annual losses of the gas, which is the main constituent of natural gas fuel. It also represents more than $9 billion in damages from associated climate effects. ▮

Astronomy

Sleeping black hole is way more massive than it should be

Jonathan O'Callaghan

A BLACK hole in the early universe has almost half the mass of its host galaxy despite no longer sucking in matter, raising questions about how these cosmic monsters grow.

While Ignas Juodžbalis at the University of Cambridge and his colleagues were looking through data from the James Webb Space Telescope (JWST), they found something unusual.

"Maybe black holes did form from the first stars and just grew at a very high rate"

It was a faint galaxy, seen from our perspective as it was about 800 million years after the big bang, with a central black hole almost half the mass of the galaxy itself – 400 million times the mass of our sun and thousands of times more massive than expected (arXiv, doi.org/mmdq).

Active black holes usually emit radiation, but this one was very faint, meaning the black hole must be dormant, having quickly grown to its large size earlier in its life.

"It's one of the lowest luminosity black holes that we see," says Juodžbalis. "Our finding implies strong evidence in favour of black holes in the early universe growing in very fast bursts."

Most galaxies, including our own, contain a supermassive black hole at their centre, but these are typically much smaller than the host galaxy. The Milky Way's central black hole is 10,000 times less massive than the galaxy, for example.

The black hole that Juodžbalis's team found seems to have stunted the growth of its galaxy, so star formation hasn't yet begun in earnest.

"This is the most overmassive black hole that has been found," says Fabio Pacucci at the Harvard-Smithsonian Center for Astrophysics in Massachusetts.

Such overgrowth could have resulted from this galaxy merging with another, which "force-fed" the black hole, says Juodžbalis. Such periods of black hole growth might last for just 4 million to 10 million years, so the chance of observing a black hole in this phase is slim.

Another merger in future could restart the black hole's growth, but it is more likely that the galaxy will eventually undergo star formation and grow into a more regular galaxy, says Juodžbalis. "It's still acquiring fresh gas."

Pacucci isn't sure this is an archetypal example of galaxy growth, however. "I think this is a very interesting and peculiar source," he says. "I don't think this is the normal pathway galaxies go through."

The unusual size of the black hole might explain how supermassive black holes grew in the early universe. Some astronomers think the first stars exploded as supernovae and created small black holes 10 to 100 times the mass of our sun that grew rapidly. Others suspect that clouds of gas collapsed directly into black holes 10,000 to 100,000 times the mass of our sun.

Juodžbalis and his team's black hole could favour the former scenario. "We're alleviating the need for having a lot of direct-collapse black holes that formed heavy," he says. "Maybe black holes did form from the first stars and just grew at a very high rate."

Finding further such galaxies could provide answers. "We are going below the tip of the iceberg in luminosity," says Pacucci. "You would expect that going lower in luminosity, you would find lower-mass objects. This paper is throwing up that this is not the case." ▮

An artist's impression of a black hole

JURIK PETER/SHUTTERSTOCK

Health

Nasal spray could help to treat MS

AN ANTI-inflammatory nasal spray reduces the severity of symptoms in a mouse model of multiple sclerosis (MS), suggesting it may treat the condition in humans.

MS occurs when the immune system damages the protective myelin that covers nerves. This leads to vision problems, difficulty walking and other symptoms.

Veit Rothhammer at the University of Erlangen–Nuremberg in Germany and his colleagues have used a nasal spray containing the anti-inflammatory molecule HB-EGF to treat seven mice with MS-like symptoms. After 15 days, mice treated with it displayed fewer symptoms than a control group. Other experiments showed that the spray increased myelin (*Nature Immunology*, doi.org/mmjk). **Grace Wade**

DP WILDLIFE INVERTEBRATES/ALAMY

Environment

Many ski resorts to lack snow by 2100

SKIING in many parts of the world will face being wiped out as the grip of climate change tightens.

Veronika Mitterwallner at the University of Bayreuth in Germany and her colleagues modelled greenhouse gas emissions scenarios for the rest of this century to predict future changes in snowfall in seven regions across the world. They have found that 13 per cent of ski areas are projected to completely lose natural, annual snow cover by 2100. And 20 per cent of skiing areas worldwide will lose more than half of their days of snow cover by the period of 2071 to 2100, relative to historical baselines (*PLoS One*, doi.org/mmjf).

The results show what we are already beginning to observe, says Mitterwallner. "More and more ski resorts are closing due to lack of snow." **James Woodford**

Zoology

City lights may have made moths evolve smaller wings

MOTHS trying to survive in bright cities may have evolved smaller wings to limit how much they are drawn in by the light.

Artificial light shining at night disrupts the lives of many insect species, diverting them from their habitats and mates and exposing them to predators.

To see if this might have caused evolutionary changes in moths, Evert Van de Schoot at the Catholic University of Louvain in Belgium and his colleagues analysed the wing and body size of 680 spindle ermine moths (*Yponomeuta cagnagella*, pictured). These moths were preserved from a previous experiment testing their responses to light.

In that experiment, researchers collected moth larvae from bright urban settings and dark rural places in France and Switzerland, then raised the moths together in the same garden. In a "flight-to-light" test, 30 per cent fewer urban moths were captured in a light trap than rural moths, suggesting they had a weaker response to light.

Van de Schoot and his colleagues may now have an explanation for this. They found that the moths from urban settings had smaller wings on average than the moths from rural areas. Among both populations, smaller wing size was correlated with a weaker response in the light trap experiment (*Royal Society Biology Letters*, doi.org/mmh8).

Having smaller wings may limit how far and fast moths go to find mates or food. But that might be beneficial in urban ecosystems if it makes the moths less susceptible to the negative effects of responding strongly to light, says Van de Schoot. James Dinneen

Really brief

ETH ZURICH

Parkour robot gets over obstacles

A four-legged robot can quickly figure out how to navigate obstacle courses by climbing up and down large boxes, crouching to scoot beneath tables and jumping across gaps. It does so thanks to artificial intelligence training that helps it to adapt to new environments (*Science Robotics*, doi.org/mmjp).

Giant redwoods thrive in the UK

Giant sequoia trees (*Sequoiadendron giganteum*) are growing just as quickly in the UK as in their native California, according to laser scans of 97 of the trees, also known as giant redwoods, from groves in Scotland and south-east England (*Royal Society Open Science*, doi.org/mmkh).

Strongest sound laser ever made

A laser that shoots particles of sound, known as phonons, instead of light is the strongest one yet. The device uses a reflective cavity, a tiny bead and an electrode to create a laser beam of sound particles 10 times more powerful and much narrower than other phonon lasers (arXiv, doi.org/mmkk).

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All in your genes

As DNA testing becomes routine, will life insurance companies start using our genetic code to inform their decisions, asks **Jenny Kleeman**

YOUR life insurance company doesn't care how much you think your life is worth, so long as you are prepared to pay a premium that covers your chosen sum. Instead, insurers are concerned with how likely it is that you will die before the end of your policy, because that determines whether they have to pay out.

Despite actuarial science remaining something of an art at the moment, the number of data points insurers can use to measure our likelihood of an early death is growing exponentially. As well as our family history of illness, whether or not we smoke and the number of units of alcohol we drink a week, insurers can also factor in the number of hours we sleep, how regularly we visit the gym and even, potentially, our browsing habits and social media profiles. But one source of information remains off-limits: our genetic predisposition to certain health conditions.

In the UK, there is a voluntary moratorium on the use of genetic information by insurers, the Code on Genetic Testing and Insurance, renewed every three years. Health insurers in the US are also barred from using genetic information to calculate risk, but there is no federal law to prohibit its use by life insurance companies, although they have yet to do this in practice.

Genetic testing – out of medical necessity or genealogical curiosity – is becoming routine. Millions of us have already sent our DNA off to be analysed by genome sequencing companies. In doing so, we might reveal the genetic health predispositions of our siblings and children, as well as our own risks. It is an enormous, untapped reservoir of data.

ADRIÀ VOLTÀ

To date, the insurance industry appears to accept that DNA can't reliably predict our medical future. When it comes to health, our genes are more of a weather forecast than an architect's blueprint: they might reveal a predisposition to certain conditions, but they can't say with certainty whether a person will develop a specific health problem in their lifetime. Except in the case of a few serious illnesses, having the genes for a deadly condition isn't a death sentence. It would be wrong for people with "bad" genes to be excluded from cover or forced to pay higher premiums, simply on the basis of having them. After all, while we can choose how much we drink and sleep, we can't change our genes.

But in the age of artificial intelligence and big data, will insurers continue to be happy to ignore data points that may make their estimates more accurate? It is easy to imagine a day when a vial of blood or a drop of saliva is as necessary a part of qualifying for an insurance policy as filling in those endless questionnaires.

If and when that day arrives, what rights would we have to the genetic data insurance companies hold on us? Would they be under any obligation to tell us what they had discovered in our DNA that informed their decision? Would we want to know?

Now that an increasing number of financial decisions are made by algorithms that scrape all possible sources of information about an individual, I am concerned by the risks associated with adding genes into the mix. If my brother's genetic test comes back showing a predisposition to Alzheimer's, I wouldn't want that to preclude me from getting cover. Additionally, I want the right to know nothing about what my genes indicate about my future health.

The UK's moratorium on genetic testing for insurance is next due to be reviewed in 2025. Whether our genes enter into the equation depends on how reliable those genetic forecasts become, and how willing we might be to surrender our DNA in exchange for lower premiums. My hope is that government, industry and customers would prefer insurance cover to remain something of an art, rather than a precise science. ▮

Jenny Kleeman is author of *The Price of Life: In search of what we're worth and who decides*

This changes everything

Is the truth out there? A recent paper packed with delightful acronyms digs into where people report having seen UFOs, but finds no evidence of alien visitors, says **Annalee Newitz**

Annalee Newitz is a science journalist and author. Their latest novel is *The Terraformers* and they are the co-host of the Hugo-winning podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is **techsploitation.com**

Annalee's week

What I'm reading
Stuart Hall's classic media studies essay Encoding/Decoding, *which is still relevant.*

What I'm watching
Dungeon Meshi, *an anime about dungeon-to-table cooking.*

What I'm working on
Making Google Gemini say weird things.

This column appears monthly

MY FAVOURITE subgenre of scientific papers is "let's please take this thing seriously even though it's usually associated with conspiracy theories and cheesy sci-fi movies". And so it was with glee that I dived into a recent example with the highly technical title "An environmental analysis of public UAP sightings and sky view potential". Translation: "We looked at where the most people saw UFOs and correlated that with how easy it was to see things in the sky."

I want to stress at the outset that this isn't a silly paper, and I'm not implying that we shouldn't study UFOs as cultural or physical phenomena. The authors, two geographers and a military intelligence expert, are painfully aware of how goofy their research might sound to some readers, and their methods of analysis are completely reasonable.

With that out of the way, I would like to celebrate a few of the acronyms I learned by reading this paper. We shall now refer to UFOs as UAPs, or "unidentified anomalous phenomena", partly to sidestep the stigma of the pseudoscientific UFO community and partly, I assume, to allow future generations to gather data on giant monsters and other such anomalies not captured by the term "flying object".

The authors used data from NUFORC, which sounds like a 1970s new wave band, but actually stands for National UFO Reporting Center. You can divulge sightings at its website, and a growing number of people did so during the period studied – 2001 to 2020 – largely due to the greater number of sensors, phones and other technologies that allowed them to record peculiar things in our environment. To study the geographical distribution of these sightings, the authors looked at roughly 200,000 reports on a county-by-county basis in the US. What they found was that more people say they have seen UFOs – erm, UAPs – in the western part of the country, where low population means darker skies overall.

But how exactly did the researchers figure out where all these sightings came from? That brings us to VGI, or "volunteered geographical information", which the authors acknowledge is "volunteered either knowingly or unknowingly by individuals, typically with the assistance of location-enabled digital tools".

"The most commonly reported UFOs turn out to be either a Starlink satellite or the planet Venus"

Many phone cameras and apps automatically log the geographical coordinates on pictures you take, whether you know it or not. This is great for friendly scientists looking for data on UAPs, but VGI also gets used in the US by law enforcement and marketing firms to suss out where you are at any given time.

But perhaps my favourite acronym is AARO, or the All-domain Anomaly Resolution Office, a delightfully named unit within the Department of Defense where one of the authors, Sean Kirkpatrick, worked until he quit in disgust late in 2023. The AARO may sound like it was invented by Charles Stross for his *Laundry Files* series of fantasy novels, but in fact it was convened to determine whether the military secretly had alien "biologics" and spacecraft in its possession. Kirkpatrick told the US Congress the answer was a resounding "no", then resigned when conspiracy lovers in and out of government continued to insist that there must be something extraterrestrial stashed in the giant warehouse where the Pentagon keeps the Ark of the Covenant and the Holy Grail.

As you might guess from Kirkpatrick's involvement with this paper, the authors don't find evidence of alien visitors. What they do find, by correlating the VGI-labelled sightings with data collections that contain the locations of military bases, airports, light pollution, cloud cover and tree canopy, is that most UAPs are spotted in places where it is really easy to look deep into the night sky. According to NUFORC, the most commonly reported UAP turns out to be either a Starlink satellite or the planet Venus. Other reports come from places where it is easy to see human-constructed objects, such as airplanes or drones, moving in swift, irregular patterns through the heavens.

There is also a higher preponderance of reports from areas with "cultures of paranormal ideation", such as the region around Roswell in New Mexico, the site of a purported UFO crash in the 1940s. Still, the researchers conclude, there are sightings that can't be explained.

What this paper confirms is that people who report UAPs aren't mentally ill or hallucinating. There is legitimately weird stuff in the sky. Maybe it isn't aliens, but our environments produce odd visual effects all the time that are both bizarre and real. And the heavens are full of fantastical objects humans have built, as well as unknowns. Analysing anomalies with scientific rigour doesn't dispel wonder, it reveals that we can witness wonders every day, right in our own backyards. ▮

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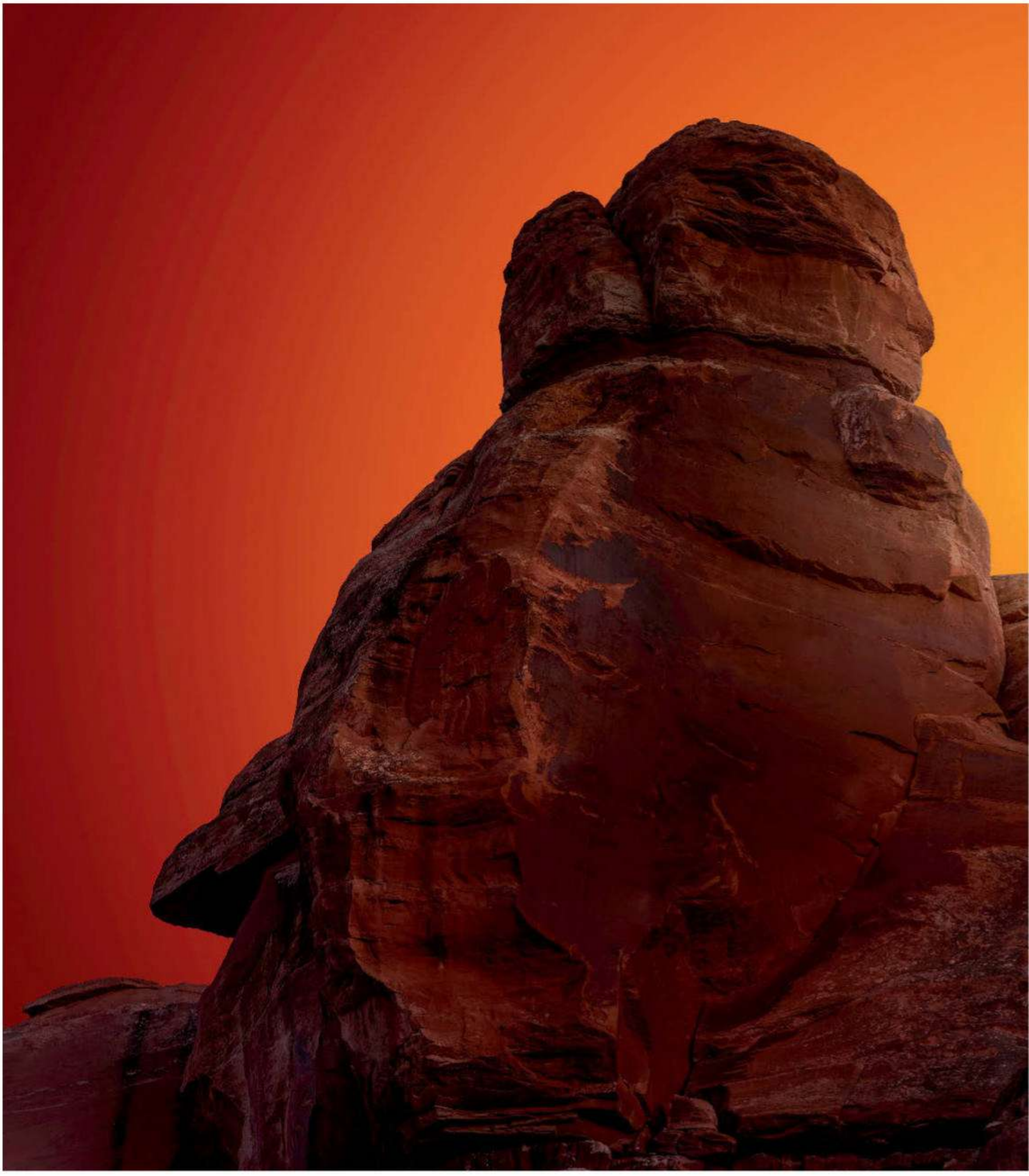

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Ring of fire

Photographers Andrew McCarthy and Daniel Stein

THIS captivating shot, showing the sun and full moon perfectly aligned over the Valley of the Gods in Utah last October, amps up anticipation for next month's total solar eclipse in North America.

A collaboration between photographers Andrew McCarthy and Daniel Stein, the image shows an annular solar eclipse, where an outer "ring of fire" forms because the moon is too far from Earth to fully cover the sun. The shot is the result of thousands of images pieced together digitally, pairing Stein's landscape photography skills with McCarthy's experience at capturing images of the sun.

After months of planning, the pair got their crucial shots by positioning cameras and telescopes at a carefully selected desert location, taking into account aspects like weather patterns, eclipse duration and landscape features.

The image was released on social media on 8 March, exactly one month before a total solar eclipse will pass over North America, during which the moon will entirely cover the sun. It will shroud many parts of the continent – from Canada to the US and Mexico – in darkness, or totality. The path of totality is due to be much wider than the last such eclipse that occurred in the region: almost 200 kilometres will be covered, compared with about 115 kilometres in 2017.

"It's easy to take the sun for granted... but when the [sun and moon] combine during an eclipse, it is breathtaking. We feel bringing in the landscape element then adds a sense of grounding to the image, allowing the viewer to really connect with the piece," says Stein.

Gege Li

Editor's pick

There is no such thing as a natural disaster

Letters, 24 February

From Terry Cannon, UCL Institute for Risk and Disaster Reduction, UK

Michael Paine wants to refer to extreme weather-related events as "climate disasters", rather than natural ones. Such disasters have never been natural, whether related to climate or geology.

That idea has been widely accepted in disasters research for at least 50 years. Disasters that emerge from a (natural) hazard event are the product of economic, political and social processes. Now, we must also contend with "natural" hazards that are also not entirely natural since a proportion of many can be attributed to global warming. This only reinforces the idea that they aren't natural, and that "climate disasters" are related to the way society makes people vulnerable and exposed to climate change.

On editing livestock to make 'greener' meat

Leader, 2 March

From Sam Edge, Ringwood, Hampshire, UK

I sympathise with your leader concerning the reduction of meat-eating's environmental impact. If people can't be persuaded to reduce their consumption then anything we can do to improve its efficiency that isn't detrimental to animal welfare is welcome.

But the argument in the last paragraph, that it may be better that customers don't know the provenance of their food, should be anathema to a science publication, surely? Haven't we had enough of governments and commerce trying to hide what is in whatever they are selling us?

From Ingrid Newkirk, People for the Ethical Treatment of Animals, Washington DC, US

You discuss manipulating animal genes to bolster meat production to allow people to keep eating what they are used to, noting that meat is a big factor in two of the greatest problems we face: global warming and biodiversity loss.

We face a third major problem: our wilful failure to acknowledge the biological fact that we are one animal among many and that every animal slaughtered is someone. As for biodiversity, there appears to be a desire to preserve various uncommon animals in some sort of species theme park while killing billions of others unlucky enough to be plentiful. And for what? A fleeting taste, a shoe? Our ethical blindness and obsession with doing whatever we want at the expense of others may well return us to the dust.

No veggie burger needs to be ultra-processed

24 February, p 21

From Anita Richards, Congleton, Cheshire, UK

Jenny Chapman makes some good points in focusing on nutrition, but why does any vegetarian food have to be ultra-processed? Caution over some margarines (those developed for profit more than for health) was warranted when the damage caused by trans fats came to light. Like most people I know, I will happily eat a veggie burger with tasty, distinct pieces of bean, mushroom and so on, but an artificial-tasting slab of mush has me reaching for a cauliflower steak.

Brain's complexity is a treasure of nature

24 February, p 32

From Andy Smith, Grimsby, Lincolnshire, UK

In comparing the complexity of the Crescent Nebula with the human brain, there may be a danger that we focus on the complexity of the structures, rather than the complexity of the outputs they produce. When evaluating the human brain in terms of output, it is hard to ignore the significance of consciousness. While this shouldn't lead us to conclude that the brain is the most complex thing in the universe, it does make it a treasure of nature.

From Gavin Maclean, Gisborne, New Zealand

You ponder whether the human brain is the most complex object in the known universe. Without a brain there is no known universe, so the converse is more empirical: the universe is the most complex object in the human brain.

If skin is so important, be careful what you put on it

2 March, p 32

From Karen Vosmer, Burry Port, Carmarthenshire, UK

If we know that the skin is the largest organ of the human body, that it acts as a protective barrier to the ravages of our environment and is a first line of defence against infections, why do millions of people cover that organ daily with a range of chemicals and microplastics?

I began to research ingredients in most of my "beauty products" about 10 years ago, and binned most of them. I now only use natural versions from reliable companies. What I put on my skin is absorbed into my body. If you created something containing the chemicals in some beauty products and told people to apply it to other organs, such as the heart, lungs, liver and kidneys, they would think you had lost the plot!

From Hugo Fair, London, UK

Given the burgeoning awareness of various types of barrier protection provided by the skin, and the possibilities of assisting this in many ways, has there been no study into the impact that may be caused by tattoos? Indeed, might it be that what you put on your skin isn't as important as what you (don't) put in it?

Equality in civility is the only way

9 March, p 21

From Maggie Cobbett, Ripon, West Yorkshire, UK

I agree with most of what Kirsty Sedgman wrote on how manners can be used to suppress others. As well as being mindful of the horrors of the past that she described, I'm old enough to remember having to sing the full version of *All Things Bright and Beautiful* at church and in school.

The verse now generally omitted had the lines, "The rich man in his castle, the poor man at his gate. God made them high or lowly and ordered their estate". Workers were expected to doff their caps to the gentry.

"Knowing your place" and "respecting your betters" were a way of life drilled into us from a very early age. My mother's respect for our family doctor almost amounted to veneration and I only began to question it when I started to mix with rackety medical students at university.

I still value civility as a way to oil the wheels of society, but only when it is extended to everyone.

Quantum computers are good for nothing

9 March, p 10

From Andrew Taubman, Sydney, Australia

The only use of quantum computers is to absorb vast amounts of research money and effort for no practical benefit whatsoever. Can I have my $5 million now please?

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Lessons from the flood

A tour of the world's great flood myths is a fascinating if stark warning about human hubris in ignoring our place in nature, says **Eleanor Parsons**

Book

Sunken Lands

Gareth E. Rees

Elliott and Thompson

ANNA BARCLAY/GETTY IMAGES

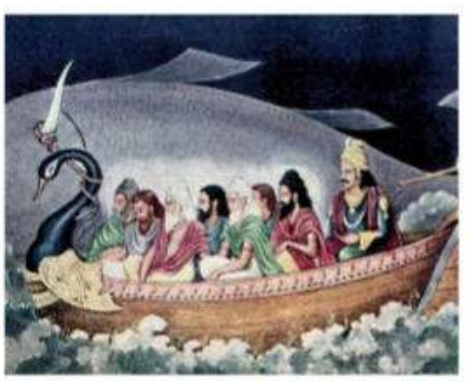
Above: Tewkesbury Abbey, Gloucestershire, UK, flooded in January. Below: Flood described in the *Mahabharata*

FOR many people, the most famous story of a great flood is that of Noah and his ark filled with animals, two by two. But it isn't the only one. There are more than 2000 myths about flooding in cultures around the world, from tales about the lost city of Atlantis to the epic *Mahabharata* from India and the legend of the submerged kingdom of Cantre'r Gwaelod in west Wales.

"Floods linger deep in our cultural memory," writes Gareth E. Rees in his book *Sunken Lands: A journey through flooded kingdoms and lost worlds*. "They ripple through songs, prayers and stories about a time of great disaster." This time, he says, could be as far back as the end of the last glacial period around 10,000 years ago, when the huge rivers of ice that covered large swathes of the northern hemisphere melted, flooding low-lying land, forests and Stone Age settlements.

In this meditation on sinking land and rising seas, Rees relates these myths and the events that may have inspired them to our current climate crisis. Watching news reports of catastrophic flooding and hurricanes, he writes that "it was suddenly easy to see how the experience of similar climate disasters in prehistory might give birth to epic myths and legends". With each discussion of the past, he sees similarities with today: the formation of the Isles of Scilly in the UK and rising sea levels around Fiji and Tuvalu, the end of the last glacial maximum and the first climate refugees in the US evacuating from Isle de Jean Charles in Louisiana, the flooding of ancient Rome and the continued building of housing on floodplains in the UK.

Rees is at his best when linking myths with the archaeological record, using these to bring to life the people who lived through the changes and the environments they inhabited. Often uncovered during storms or via fishing nets, the underwater remains of Stone Age settlements have changed our understanding of the people who lived then, showing more sophistication than we assumed.



PUBLIC DOMAIN

Just off the Isle of Wight, UK, for example, divers found the world's oldest boat-building site, "indicating the use of crafting technologies far beyond the capabilities expected of that time".

Rees also examines the folly of our exploitation of nature. He wanders the Fens in eastern England, a marshy region drained in earnest in the 17th century to make space for agriculture, which has caused the peat to dry out and the land to sink by 4 metres. He also visits Louisiana to see the effects of the oil industry on this sinking landscape. As he writes: "Our incessant drive to control the natural world... had created an ecological disaster and placed millions of people at risk of suffering terrible floods."

Part travelogue, part history, part science, *Sunken Lands* is hard to define. Each chapter opens with a short story, often a retelling of a myth or folk tale, setting the scene for what is to come. Rees is a magpie, hopping between things he finds interesting: the occult, epigenetics and David Bowie all make an appearance. While these diversions can be fun, I would have liked to read in depth about the stories and archaeology beyond Europe and the US. For example, the flooding of northern Australia after the last glacial period that

"Flood stories don't tell us how to stop climate change, but they warn against over-reliance on technological fixes"

Aboriginal peoples incorporated into their oral lore, called the Dreaming, was disappointingly only brought up in passing.

The collected flood stories serve as a warning. They don't tell us how to stop climate change, says Rees, but they do warn against over-reliance on technological fixes: "In these tales, arrogant cultures dismiss warnings that they must mend their decadent ways and live harmoniously with the natural world, only for their walls to collapse and the seas to roll in." Quite. We have forgotten we are part of nature, he argues, and only once we rethink our place in the world will we be at peace in it. ▮

No need to panic

What is all our screen use really doing to us? A new book counters the scare stories by sticking to the science, says **Chris Stokel-Walker**

Book
Unlocked
Pete Etchells
Piatkus

DURING the course of writing this review, I looked at four separate screens. There was my laptop, onto which I typed this text; there was my phone, pinging and buzzing with messages from friends and colleagues; my iPad, for hunting additional details; and, in the background, a TV passively showing programmes.

So far, so normal in 2024. But what do all those screens and the time spent with them do to us? Plenty of books and articles scream warnings about the impact of this technology on our lives. We are becoming impatient, stupider, addicted, and we need to digitally detox.

Except that we aren't and we don't, as Pete Etchells, a psychologist and science communicator at Bath Spa University, UK, explains in *Unlocked: The real science of screen time (and how to spend it better)*. In it, he walks a complicated tightrope, puncturing some of the most pernicious myths about our smartphone and screen-dominated lives, while offering good advice about how to improve the time we spend with screens.

Our relationships and lives are changing thanks to technology, writes Etchells, but we don't need to panic ourselves into pointless abstinence or reach for the language of addiction – using the term "dopamine hits" to explain tech's seemingly addictive quality lacks any scientific basis.

As a society, argues Etchells, "we have become too apprehensive – and even fearful – about screens". He says that our worries are "deeply idiosyncratic, grounded firmly in anecdote and lived experience", rather than evidence. And such evidence as there is, he says, isn't brilliant: much of the research raising the alarm comes from people self-reporting time spent with screens, hardly a good metric given most of us lack uncannily good memories. Even the newer, less subjective research suggests the effects are far less pronounced than we feared – or even non-existent.

In the Netherlands, schoolchildren must leave their smartphones outside the classroom

HOLLANDSE HOOGTE/SHUTTERSTOCK

To overcome the fear that has taken hold, Etchells suggests we stop thinking about screen time and instead focus on screen habits. The former, and worries about how much is too much, frames the argument for abstinence, while the latter is more realistic. After all, 4 hours spent working on screens is different from 4 hours listlessly scrolling through social media.

Explaining all this clearly, with useful analogies and humour (check the footnotes peppering the book), is what makes *Unlocked* a must-read. Its light prose adds a breezy style that mirrors the upside of similar books, while avoiding their downside by staying with the evidence. It feels as if you are in the room with Etchells as he writes, narrating his own relationship with tech as the father of two young children who he watches warily every time they reach for his smartphone, eyes round with wonder.

***Unlocked* is like a good podcast or popular science radio or TV series: weighty, chummy, quirky and charming. It is also a corrective, providing a realistic tonic amid the doom and gloom. Above all, it is important. Etchells has benefited from his book being released at a time when smartphone and social media "addiction" is being blamed for a multitude of social evils and tragedies. In the UK, a survey published a few weeks before this book's release found that two-thirds of the public would support a ban on selling smartphones to under-16s.**

But canny politicians (and the public) would do better to read *Unlocked*. That way, they can make informed decisions about whether such bans are needed, and if they would make a difference.

Chris Stokel-Walker is a technology writer based in Newcastle upon Tyne, UK

New Scientist *recommends*

Alexandra Thompson
Assistant news editor
London

Recently, I saw **Castle of Joy** (pictured), a harrowing and deeply moving play, at the Barbican Centre, London. Set in the mid-20th century, it tells the story of

Joy, a neurodivergent boy who lives on the Faroe Islands, part of Denmark. The islanders don't accept him and he is sent to a barbaric psychiatric institution in Denmark. We follow him there until he returns to the Faroes as an adult and builds the eponymous "castle" to help him cope.

Sadly, the real Joy (Pól Jóhannus Poulsen, also known as Lykken, "Joy" in English) went missing in 1971. His body was found five months later in the mountains. The castle burned down in 1978 – just one fragment of wood remains.

In a lighter mode, I am enjoying **Dragonfly in Amber**, the second book in Diana Gabaldon's **Outlander** series. Claire, a 20th-century time traveller, and Jamie, her 18th-century Scottish Highlander husband, become embroiled in the Jacobite uprising. Pure whimsy, but wonderful.

GWENAEL AKIRA HELMSDAL CARRE

The TV column

Facing it down

Cixin Liu's novel *The Three-Body Problem* has been turned into an eight-part series for Netflix by the *Game of Thrones* team. There is much to admire so far, but will the adaptation stay on track, wonders **Bethan Ackerley**

Bethan Ackerley is a subeditor at *New Scientist*. She loves sci-fi, sitcoms and anything spooky. She is still upset about the ending of *Game of Thrones*. Follow her on Twitter @inkerley

NETFLIX

VR allows characters to visit fantastical worlds, such as a fiery wasteland

ADAPTATION is the backbone of the modern TV industry. It is also one of the toughest jobs in the business. Done right, it can lift a lacklustre novel or dated comic book to new heights. Done wrong, it is the lowest form of dreck, unable to hide its rough edges behind an original concept.

What to do, then, when tasked with adapting one of the most acclaimed sci-fi novels of the past 20 years? And where to start when you are notorious for the failed finale of your previous book-to-TV adaptation? That is the dilemma faced by David Benioff and D. B. Weiss, the pairing behind *Game of Thrones*, who, alongside screenwriter Alexander Woo, have adapted Cixin Liu's novel *The Three-Body Problem* for Netflix.

The result is the eight-part TV version, slightly retitled as *3 Body Problem*, an era-spanning epic that combines hard sci-fi with a noir-thriller aesthetic and historical drama. In the late 1960s, Ye Wenjie (Zine Tseng) is forced to watch her father, a physicist, as he is publicly executed during the Chinese Cultural Revolution, in which Mao Zedong and his supporters terrorised their political enemies. A physics prodigy herself, Wenjie is drawn into murky research and a battle with Communist officials.

Her narrative is intertwined with a mystery set in modern-day London. In 2024, astrophysicist Jin Cheng (Jess Hong) and four friends are brought together by the death of their former university tutor. Scientists are dying in mysterious circumstances, while anomalies detected by the most accurate particle accelerators are baffling the world's physics community. Then there is the VR headset offering startling realism that Jin begins to use, inviting her to solve a centuries-old question in orbital mechanics: the three-body problem – or how three objects bound gravitationally can form a stable orbit around each other.

"Liu's novel is a brilliant, influential work, but it is riddled with sexism, which the Netflix series largely excises"

There is plenty to like about *3 Body Problem*. It presents thorny physics in a tangible, entertaining way, particularly in its VR-enabled flights of fancy to ancient China and Tudor England. It also gives Benedict Wong, a brilliant comic actor, meaty material for a change. His Clarence Shi, an unorthodox detective at a shadowy intelligence organisation investigating the deaths in the world of science, is sure to be a fan favourite.

That said, there are missteps. Like many series with a vast roster of characters and a long arc, you may be drawn to one perspective or timeline over another. Of the five contemporary friends, certain figures are weaker than others. Millionaire snack entrepreneur Jack Rooney (John Bradley), for example, can be an irritating presence, and I struggled to buy him as the crude-but-lovable scamp of the group.

Which brings me back to adaptation. *3 Body Problem* takes several diversions from its source. Some are welcome: Liu's novel is a brilliant, influential work, but it is also riddled with sexism, which the Netflix series largely excises.

Others are more mixed. Rather than being firmly tied to China's history over the past 60 years, the epic has been translated to an international stage. While this makes a certain sense, you lose much of the novel's rich context.

It is easy to criticise Benioff and Weiss. You will notice I do in my biography. Memories of how *Game of Thrones* went off the boil after it outpaced the books it was based on are still raw. But they and Woo have, on the whole, done a good job with a hard brief, casting a bold eye over revered material. ▮

TV

3 Body Problem
David Benioff , D. B. Weiss and Alexander Woo
Netflix

Bethan also recommends...

TV

The Terror: Infamy
Alexander Woo
Amazon Prime Video (UK); Hulu (US)
This horror series shines a light on a bleak moment in history as Japanese citizens in the US were forced into internment camps.

Book

A View From The Stars
Cixin Liu
Tor Books
Not a recommendation, but a reminder that this collection of Liu's fiction and essays is due out in April.

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Strange... but true?

Theories of fundamental reality are inescapably weird, but that doesn't mean they are wrong – and we can all figure out how seriously to take them, says philosopher **Eric Schwitzgebel**

ARE there vastly many near-duplicates of you reading vastly many near-duplicates of this article in vastly many parallel universes? Is consciousness a fundamental property of all matter? Could reality be a computer simulation? Reader, I can hear your groans from here in California.

We are inclined to reject ideas like these on the grounds that they sound preposterous. And yet some of the world's leading scientists and philosophers advocate for them. Why? And how should you, assuming you aren't an expert, react to these sorts of hypotheses?

When we confront fundamental questions about the nature of reality, things quickly get weird. As a philosopher specialising in metaphysics, I submit that weirdness is inevitable, and that something radically bizarre will turn out to be true.

Which isn't to say that every odd hypothesis is created equal. On the contrary, some weird possibilities are worth taking more seriously than others. Positing Zorg the Destroyer, hidden at the galactic core and pulling on protons with invisible strings, would rightly be laughed away as an explanation for anything. But we can mindfully evaluate the various preposterous-seeming ideas that deserve serious consideration, even in the absence of straightforward empirical tests.

The key is to become comfortable weighing competing implausibilities, something that we can all try – so long as we don't expect to all arrive at the same conclusions.

Let us start by clarifying that we are talking here about questions monstrously large and formidable: the foundations of reality and the basis of our understanding of those foundations. What is the underlying structure of the universe and how does human consciousness fit into it?

It isn't that we don't have theories that attempt to answer these questions. Rather, we have too many, and no straightforward way to put them to the test – nor any realistic prospect of doing so any time soon. This is where weirdness and bewilderment reign.

To be more specific, my argument is that all broad-ranging attempts to articulate the fundamental structure of reality, no matter how soberly we approach them, inevitably become both bizarre and dubious. Bizarre, in that they defy common sense. And dubious, in that they allow for reasonable doubt. These twin theses of "universal bizarreness" and "universal dubiety" in fundamental matters of metaphysics and cosmology form the basis of my latest book, *The Weirdness of the World*.

Consider interpretations of quantum mechanics. We have a set of equations that describes the behaviour of the subatomic particles that comprise matter and the forces through which they interact. That behaviour is famously strange. But the equations of quantum mechanics aren't particularly dubious, having passed every experimental test we have thrown at them.

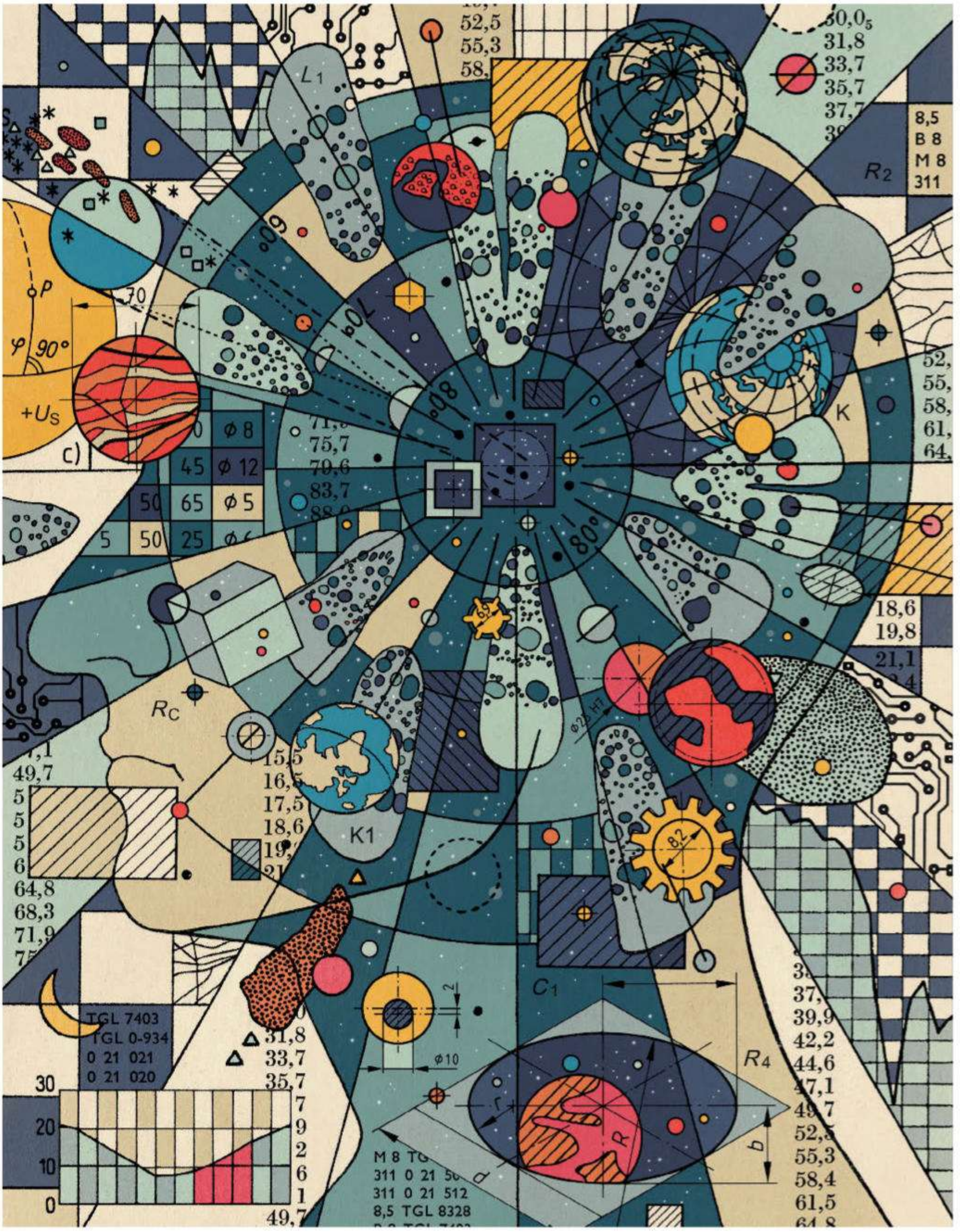
"Some are happy to let common sense go if it yields a cleaner hypothesis"

It is when we attempt to assess what they tell us about the nature of reality that we confront their full bizarreness and dubiety. According to some interpretations, for example, the act of observing a quantum object collapses its "wave function", the mathematical entity that encodes the probabilities of all possible outcomes. In these interpretations, particles exist in a quantum fog until our observations distil them into hard-edged classical reality.

The thought experiment known as Schrödinger's cat illustrates the bizarreness of this view. A cat is trapped in a box with a poison that may or may not have been released. It exists in a "superposition" of alive and dead until the moment someone peers into the box and collapses the wave function.

According to "objective collapse" interpretations, resolving the wave function into one outcome needn't rely on human observation and is itself a matter of chance. Schrödinger's cat could, in principle – though it is unlikely – remain in the alive-dead superposition even after we observe it. Still other interpretations, known as Bohmian mechanics after the physicist David Bohm, posit a faster-than-light "pilot wave" that determines outcomes in quantum systems.

Then there are interpretations that predict no collapse at all. According to the "many worlds" interpretation, the cat ›



CHRISTIAN GRALINGEN

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remains always in the superposition of alive and dead. When we open the lid, we join the superposition, and hence from that moment also exist in two possible states: a version of us sees the cat as alive and another sees the cat as dead, and these two versions of us go on to lead different lives in different "worlds" – one in which the cat died, with all the consequences of that, and one in which the cat lived.

Such world-splitting would be extremely common, occurring, for example, almost every time a photon passes through polarised sunglasses. Hence, according to many worlds, there are vastly many near-duplicates of you reading vastly many near-duplicates of this article in vastly many parallel universes.

That might seem utterly preposterous. But the same could be said of all other interpretations of quantum mechanics, and that is the point. They are all bizarre and dubious, in different respects and for different reasons. Many worlds's bizarreness can't, therefore, be decisive evidence against it. No non-bizarre interpretation is currently available, nor likely to be waiting in the wings.

That shouldn't be surprising. Common sense evolved to help us negotiate the world as we see it – comprising middle-sized objects and low velocities – and we ought not to expect it to help much beyond that domain.

Nor do any of the interpretations entirely compel belief. For the foreseeable future, there is no decisive empirical test we can run that will straightforwardly settle the question of which is the correct one.

So, something ragingly weird must be true about the quantum realm. But which of the various preposterous-seeming possibilities is in fact correct? The truth is that we are in no good position to know. We have reached the limits of science and philosophy, leaving us all – experts or otherwise – in a similar position.

But here's the thing: some theories do fit a bit more naturally with the empirical evidence, and each has its own virtues, such as simplicity, elegance and fruitfulness in suggesting new research directions. It is on these grounds that we can compare bizarre theories and pick favourites.

Many worlds, for example, is more sharply at odds with common sense than most of the other interpretations of quantum mechanics. Since we have to start our thinking somewhere, that is a strike against it. Violations of common sense have to be earned.

On the other hand, many worlds has advantages in terms of theoretical elegance. There is no wave function collapse to worry about, so no need for a model of what really happens during collapse. And, arguably, it fits with the empirical evidence more naturally than other ideas, since there are no speculative collapse dynamics that remain undiscovered.

In contrast to many worlds, with objective collapse interpretations there is always a chance of collapse, too rare to be seen in experiments on individual particles but common enough to be nearly instant in macroscopic systems. Other interpretations attribute collapse to the act of observation – but what is "observation", and why should it cause collapse?

Although bizarre, such ideas aren't quite as bizarre as many worlds. On the other hand, the speculative claims about collapse make them less empirically simple and elegant. However, there is a way in which collapse theories are simpler, since they prevent the proliferation of worlds. They are, in that respect, leaner as far as metaphysics is concerned.

How you weigh up such competing virtues is down to you. Some of us are happy to let common sense go if it yields a cleaner idea. Others more stubbornly hold to it until forced to do otherwise. Scientists and non-scientists can reasonably disagree about such matters, within certain parameters.

Those parameters are important. The idea that Zorg the Destroyer causes quantum collapse from his hiding place in the galactic core, for instance, has no merits. You should roll your eyes at that. But when it comes to many worlds, you can appreciate the general structure of competing considerations and reach your own educated guess.

We can apply similar thinking to panpsychism, the idea that consciousness is a fundamental property of matter, always present, rather than something new that arises only when matter is combined in the right way.

The people who give credence to panpsychism do so for two main reasons. First, it isn't at all obvious how something as distinctive as full-colour conscious experience could arise from humdrum physical matter, and panpsychism offers a solution. If all matter has some small degree of consciousness, it is easier to see how it might combine into the more complex consciousness we know.

There are other ways to explain consciousness, of course. They include substance dualism, which holds that mind and matter are fundamentally distinct; a priori physicalism, which argues that consciousness somehow emerges from ordinary physical

TIMOTHY A. CLARY/AFP VIA GETTY IMAGES

In the quantum multiverse, there are many versions of you

How certain are you that we don't live in a computer simulation?

SAHA ENTERTAINMENT/GETTY IMAGES

matter; and illusionism, the idea that the very concept of consciousness is unscientific. But each faces its own troubles.

As far as panpsychism goes, the second reason to give it credence lies in the challenge of drawing the line between organisms or systems with and without consciousness. Logically, there are four options. Everything is conscious, as in panpsychism; nothing is conscious; there is a hard line between conscious and non-conscious systems; or there is a fuzzy line between conscious and non-conscious systems. Any strikes against the final three options should make us favour panpsychism.

Presumably, you know that you are conscious. That rules out the nothing-is-conscious option. Arguably, it is theoretically inelegant and empirically untenable to posit a hard line between conscious and non-conscious organisms, given that living things exist on a continuum of psychological capacities and behaviours. That rules out the hard-line option. And it is difficult to understand how there could be a fuzzy boundary between conscious and non-conscious systems. What would it even mean for a system to be "kind of" conscious, standing somehow between having subjective experiences and not having subjective experiences? Ruling out those three options would leave you with panpsychism.

But we can reasonably resist the panpsychist conclusion. In my own research, I have defended the existence of a fuzzy line between conscious and non-conscious systems. We ought to accept – though it is difficult and maybe even impossible to conceive – that between no experience and some little flicker of experience lies a half-something that is neither a nothing nor a something.

I have phrased that paradoxically to bring out its poor fit with our conceptions of consciousness. As soon as we imagine an entity as conscious, we imagine it as having some consciousness or other, however vague or minimal, or we don't imagine it as conscious at all. I can see why people might want to resist the fuzzy-line view.

So how do we choose? Here, again, we are past the point where knowledge and expertise can settle the question, and we can all exercise our independent judgement within a range of reasonable options.

Panpsychism elegantly handles both the puzzle of how consciousness fits into a physical world and the puzzle of how to draw the boundary between conscious and non-conscious entities. Much like many worlds, it strains mightily against common sense, while having an attractive simplicity.

"Panpsychism elegantly handles the puzzle of how consciousness fits into a physical world"

Simulated realities

Which leaves the last of the three questions we began with: how can we assess the idea that we are all living in a computer simulation?

Clearly, we are still far from a consensus scientific theory concerning the nature of consciousness. But many potential explanations suggest that it is, at least in principle, possible to create consciousness in artificial intelligence systems. So, suppose you allow that there is a good possibility, in principle, of such a consciousness arising somewhere, someday, using some technology. And if you allow that, you should probably also allow that some of these conscious AI systems live entirely within simulated environments, receiving inputs from computational outputs – roughly akin to what a human experiences when they don virtual reality goggles. Such AI systems would be living inside simulations, though they might not know it.

If we grant this pair of possibilities, then there is a basis for wondering whether many such AI systems exist – and we can wonder if we are among them.

There is also a basis to resist this, of course. Maybe no AI system could ever be conscious. Maybe genuinely conscious AI systems living in simulated realities would be expensive, and technologically advanced designers would have little motive to create them. Maybe the fact that we haven't noticed any glitches in our reality constitutes some empirical evidence against the simulation hypothesis.

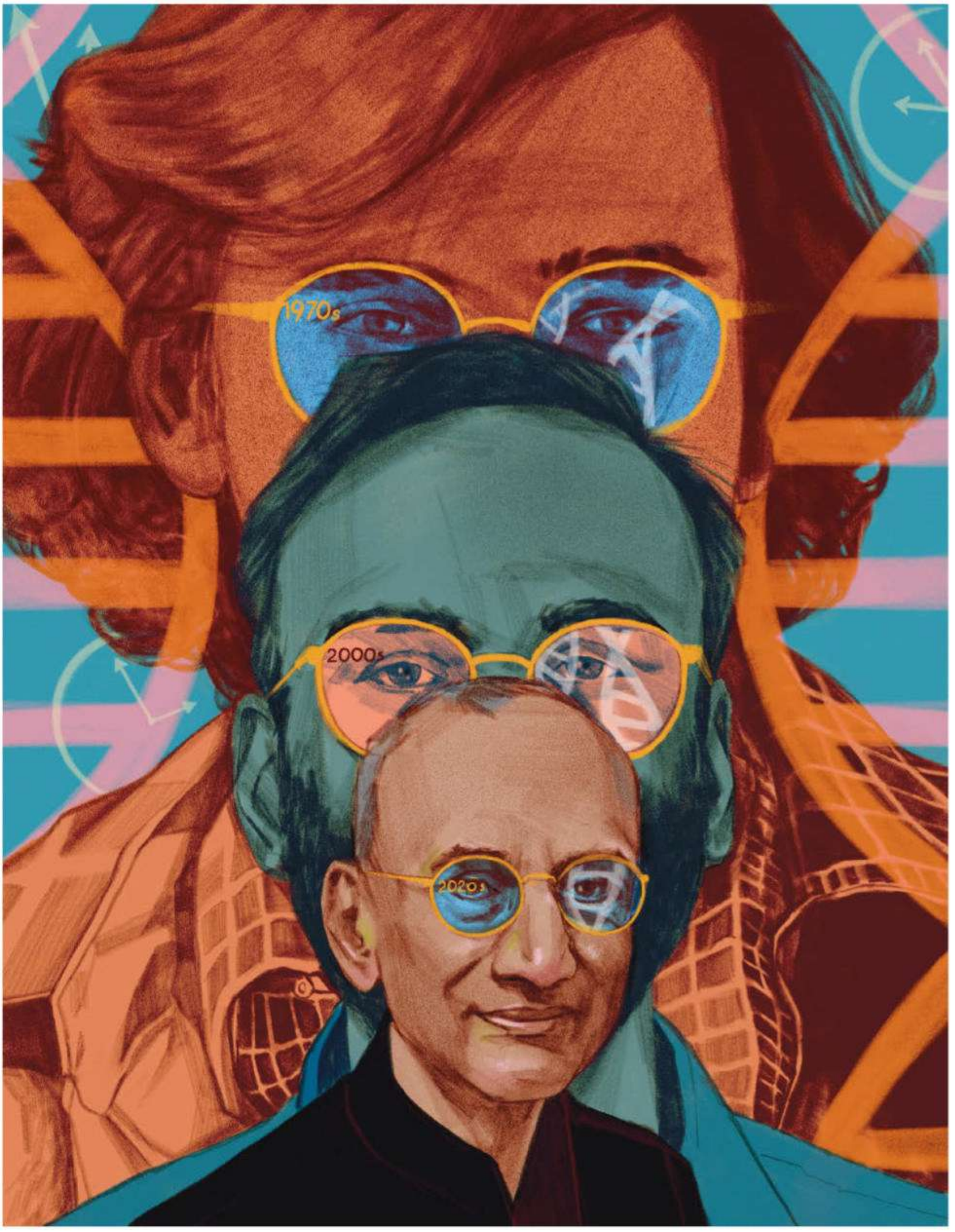
Alternatively, maybe conscious AI systems living in virtual realities would be relatively inexpensive for sufficiently advanced societies. Designers might create them for science, entertainment or because they regard it as ethically worthwhile to create worlds full of rich, meaningful life.

Stacking up the possibilities, we might regard it as highly unlikely that we live in a simulation. But it isn't Zorg territory. The possibilities aren't so remote and absurd that we should disregard them. Perhaps we ought to be 99.9 per cent confident we don't live in a simulation. But in light of our ignorance about consciousness and fundamental cosmology, and in light of the bizarreness and dubiety of all theories in this area, it seems hard to justify a level of 99.999999 per cent confidence that the simulation hypothesis is false.

At which point, you might be wondering if we are resigned to confusion. Will we never know the right interpretation of quantum mechanics, or the grounds of consciousness, or whether we live in a simulation?

Not necessarily. Science can reveal answers to questions that previously seemed unsolvable. What once appeared bizarre can become comfortable and familiar. But as we await new empirical evidence to support or refute many worlds or panpsychism, we can delight in our ignorance. We can celebrate the diversity of wild options and the weirdness of the world. How boring it would be, after all, if there were no bizarre metaphysical possibilities to wonder about. ▮

Eric Schwitzgebel is a philosopher at the University of California, Riverside. His latest book is *The Weirdness of the World*



ULA ŠVEIKAUSKAITĖ

‘This idea that we’re going to solve ageing tomorrow is highly optimistic’

Efforts to extend our lifespan continue, but success will have unintended consequences, **Venki Ramakrishnan** tells Graham Lawton

ANTI-AGEING is big business. From books encouraging diets such as intermittent fasting to cosmetic creams to combat wrinkles, a multibillion-dollar industry has been built on promises to make us live longer and look younger. But how close are we really to extending our lifespan in a way that gives us extra years of healthy life?

Nobel prizewinner Venki Ramakrishnan, a molecular biologist and former president of the UK’s Royal Society, is the latest to tackle this question. He has spent 25 years studying the ribosome, which is where our cells make proteins using the information encoded in our genes, at the MRC Laboratory of Molecular Biology in Cambridge, UK.

In his latest book, *Why We Die: The new science of ageing and the quest for immortality*, he goes on a journey around the cutting-edge biology of human ageing and asks whether it will be possible to extend our lifespan in the near future.

He talks to *New Scientist* about the recent breakthroughs in our knowledge of what causes ageing, how close we are to creating therapeutics to combat it, and the potential consequences if we succeed.

Graham Lawton: What inspired you to take a break from a hugely successful career researching how cells make proteins to write a book about ageing?

Venki Ramakrishnan: Two things. One is that the translation of genetic code into proteins affects almost every biological process, and it turns out to be central to many aspects of ageing.

The other reason is that we have worried about ageing and death ever since we became humans. For most of our existence as a species, there was very little we could do about it. But because of the tremendous advances in biology over the past few decades, we now have tools and a level of knowledge to think about what causes ageing and what we could do to either ameliorate it or postpone it.

At the same time, there’s a huge amount of hype in this field. I thought that, as a molecular biologist who understands the broad field while not being in it, who doesn’t have an agenda or any companies involved in ageing, I was perfectly positioned to take a very hard look at what’s going on and ask: what are some of the real things we know about ageing and what are the prospects for the future? ›

FLASHPOP/GETTY IMAGES

Do you think we fully understand the main causes of ageing?
No. Ageing occurs at every level, from the molecular to the cellular to the organs and the entire body, and it has multiple causes that are highly interconnected. Cause at one level can influence cause at a more basic level and vice versa. If some entirely new aspect of ageing were to come about, I don't think the researchers would quibble.

But we understand it enough to start thinking about interventions?
Yes, I think that's a fair comment. The idea is that a cell doesn't want to spend too many resources trying to prevent ageing because it comes at a cost, and it's not worth it if you're going to die anyway, such as by starving or being eaten by a predator. Our life expectancy has doubled over the past 150 years, so we encounter all these diseases of ageing that, in the past, very few of us would have encountered. As we start to understand the biological basis, people are trying to intervene.

What do you see as the most promising avenues for interventions against ageing?
One very exciting area is stem cell regeneration and cellular reprogramming. Stem cells and regenerative medicine are already established areas with a lot of promise and some people are segueing into anti-ageing research. The idea is to reprogram cells so that you can perhaps reverse them back to an earlier stage so they're capable of regeneration. But it's early days.

> "We have worried about ageing and death ever since we became humans"

What other approaches are there?
Everybody agrees DNA damage is a fundamental cause of ageing, but so far [work on] DNA repair, and therapeutics targeted at that, has been mostly to address cancer rather than ageing.

But there are people working on telomere loss. Telomeres are the ends of our DNA strands. When you replicate DNA [during cell division], you start losing the ends. If you kept losing the ends, you would start going into the part of the chromosome that codes for important information.

How close are we to gaining extra years of healthy life?

There's an enzyme, telomerase, that adds telomere sequences every time there's a replication, but it turns out we shut off telomerase in most of our cells, except for certain cells that have to live for a very long time, like stem cells. Many of our cells, like our skin cells and hair cells, have often lost telomerase, and so the question is, could you reactivate telomerase and regenerate these tissues? There are people who are studying that and there's some initial promise. I would say [reactivating telomerase] is probably most likely to help with diseases where you have telomere loss, and only after that will we know whether it's a general thing against ageing.

Another approach involving DNA damage we are hearing more about is senolytics. What is this?
When you have DNA damage or you have extreme telomere loss, the cell can go to two outcomes. One is [cell] suicide, a phenomenon called apoptosis. The other is to go into a "senescent" state where it stops dividing and is no longer functional in the usual sense. But it turns out these senescent cells aren't just quietly sitting there – they're secreting inflammatory molecules. These are triggers for the immune system to come and do repairs.

If you accumulate senescent cells, you get inflammation, and if you specifically kill senescent cells, you can alleviate many of the symptoms of ageing that are a result of inflammation. That field is called senolytics, and it seems to be promising.

How does your own specialist area, protein synthesis, tie into ageing?
When you make proteins, they usually fold up into their normal shape and do their thing, but as they age, proteins can unfold. When they unfold, they expose the inside amino acids, which are sort of sticky. And so these proteins tend to aggregate. They're bad for the cell, so the cell has lots of ways of trying to deal with unfolded proteins.

What you want to do is shut down protein synthesis. It's a bit like if you have a traffic jam, you want to stop new cars from entering. And that's what a protein called TOR does. Whenever there's stress, TOR will shut down

New Scientist video
See more of Graham Lawton's interview with Venki Ramakrishnan at youtube.com/newscientist

protein synthesis, and this seems to have an effect on ageing because it also turns on degradation and recycling pathways. These metabolic pathways indirectly slow down ageing.

This provides a biological explanation for the long-standing observation that if you calorically restrict animals, providing them with just enough calories to survive, they tend to live longer. Now, of course, nobody likes caloric restriction. Even mice. As soon as you stop caloric restriction, they start gorging on food. I think it might be easier to take a pill that has the same effect, and I joke that this is a "get out of kale free card". But actually, we're nowhere near.

That is a recurring theme in your book, a reticence to extrapolate from basic science to applications in people.
I just know from much more clear-cut areas how long it takes to go from a basic finding to something that's actually useful. Even in the best cases it takes 10 or 20 years. When you take a much more multifactorial and ill-defined process like ageing, this idea that we're going to solve it tomorrow is highly optimistic.

The anti-ageing field is also being highly distorted by the injection of huge amounts – billions and billions of dollars – of private capital. A lot of it is driven by tech billionaires. They're mostly middle-aged men and they've got everything in the world. They can buy anything they want. Except youth.

If we can eventually intervene in ageing, do you think people will want to?
I do believe if someday somebody comes up with a pill and says it'll keep you healthier for 10 years longer with no side effects, who wouldn't want to take it? I think we have to be prepared for a potential future where it might be possible, though I'm sceptical that it's around the corner.

But I'm also optimistic that eventually there may be breakthroughs that will help us overcome some of these barriers. Then we'll be in a situation where maybe we'll all be living quite a bit longer. I just don't think it will happen in my lifetime or even to anybody born today.

What do you think the consequences will be if we start living longer?
If we all start living longer and we reproduce at the same rate, then the population will start exploding. You'd have what I think of as a stagnant society. People say, "oh, but if we had 200 years to live, we would have five different careers". This is wishful thinking. I think most of our innovation happens when we're young. You look at great scientific discoveries, even great works of literature: all were done when people were relatively young. Why is that?

I think part of it is that when we're young, we approach life with a freshness and an openness. We're willing to challenge existing ideas and dogma. And that gives us a sort of creativity that we start losing as we age. So it's not simply a question of staying healthy. I'm reasonably healthy, but I don't think I'm nearly as creative as I was when I was 40.

I think this is a serious problem, especially if you look at social trends. For example, civil rights or women's rights or LGBTQ+ rights. Social changes are often driven by young people. People talk about older people: maybe they're not quite as sharp, but they have more wisdom. I'm sceptical about that too. Often, older groups are driven by conservatism born of nostalgia. I don't think that's necessarily wisdom.

We already live twice as long [on average] now as we did 150 years ago. Are people today really more creative or more prolific than Mozart or Beethoven or Charles Darwin or Isaac Newton? I don't think so.

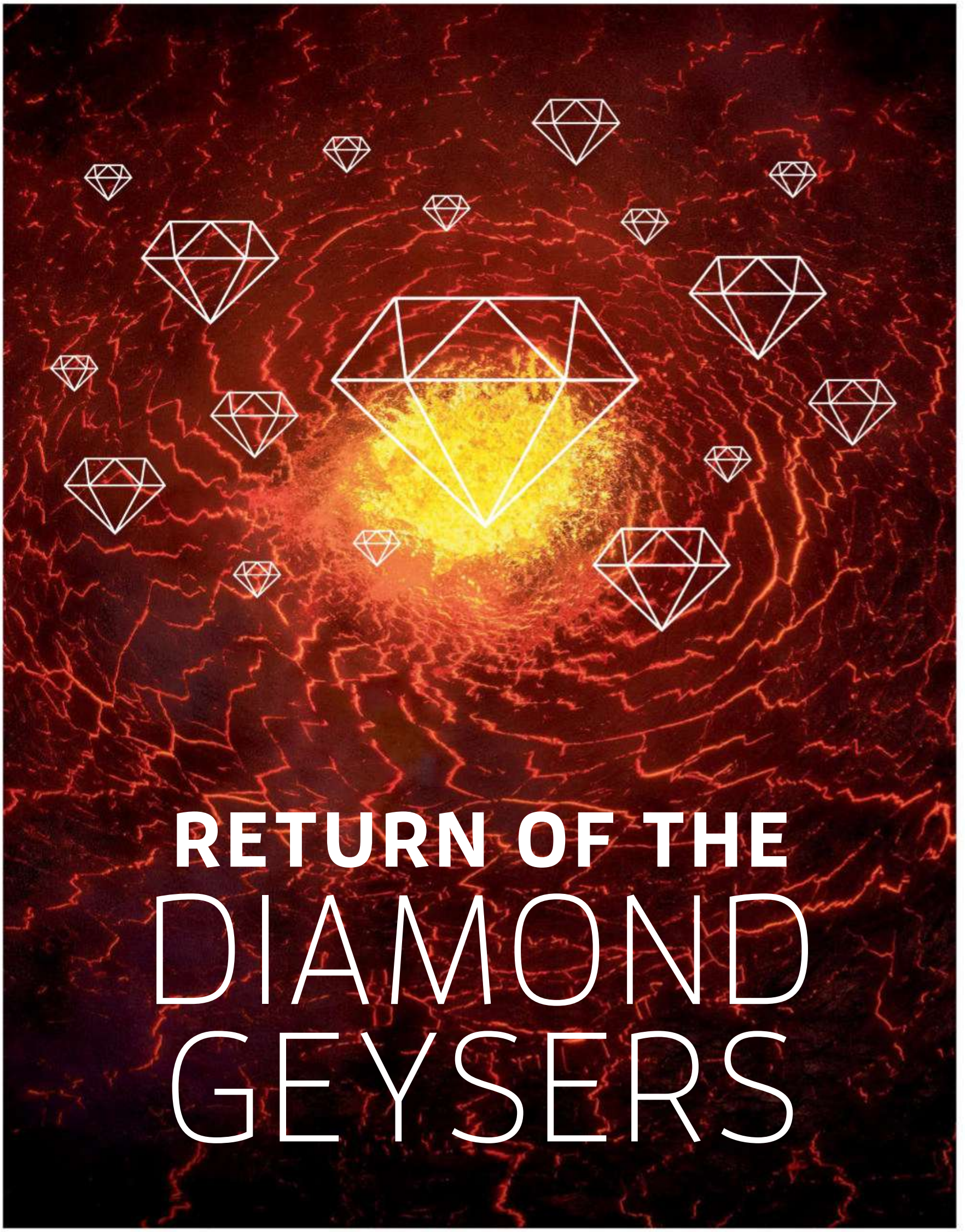
There are much more pressing issues than slowing ageing. Where would you redirect our efforts?
As someone who grew up in India, I do think this mania to live longer is a First World problem, and I think there are so many more important problems: infectious diseases, chronic diseases, malnutrition, food security, climate change. Those are all much more pressing problems than living 20 years longer.

I do think we should aim to live healthily for as long as we can. But we've got to accept our mortality as just part of the grand scheme of things. It is very hard, and I think we're deeply evolved to avoid death. It goes against our natural instinct, so it's hard work to accept it gracefully. ▮

MASKOT/ALAMY

Younger people may approach life with an openness that is lost with age

Graham Lawton is a features writer at *New Scientist*



RETURN OF THE DIAMOND GEYSERS

ARMAND SARLANGUE

Mysterious and strange volcanoes that jet diamonds to Earth's surface at supersonic speeds might not be extinct after all, finds **Robin George Andrews**

TWENTY years ago, deep beneath Botswana's Kalahari desert, Thomas Gernon found himself walking in what seemed like hell. The temperature soared as the sound of explosions echoed off the walls. "It was like a baptism of fire," he says. It was his first trip into a kimberlite diamond mine.

The place teemed with cameras and Gernon, now at the University of Southampton in the UK, had been warned of trouble should any gemstones be found – accidentally or otherwise – on his person. But he wasn't here to find his fortune. He wanted an answer to one of Earth's greatest mysteries.

Diamonds are precious to many, but they hold a special place in the hearts of geologists. They were forged long ago in the fiery depths of Earth's inaccessible mantle, brought to the surface by riding on supersonic jets of magma from bizarre volcanoes called kimberlites.

We don't know much about precisely how diamonds formed, but we do know they are like time capsules that can teach us the secrets of our planet's distant past. And perhaps the biggest question of all is why the kimberlites that propelled them to the surface seem to have gone extinct millions of years ago.

Now, almost two decades since that first visit to a diamond mine, Gernon and his fellow kimberlite detectives may finally have an all-encompassing model for how the volcanoes work, and with it a better understanding of their treasures. What's more, this work has uncovered a tantalising prospect – that kimberlites might not be extinct after all.

Diamonds, contrary to popular belief, don't come from compressed coal. Precisely how they are made isn't clear, but geochemistry studies and laboratories that mimic the extreme temperatures and pressures of Earth's depths have provided clues. Some are thought to germinate in the mantle, a solid-but-fluid layer where carbon-rich material becomes so jam-packed that excess carbon is squeezed out to grow as pure crystal prisms. Others could be made as a tectonic plate is pushed into the mantle. As it descends, it drags organic matter, including carbonate minerals from the ocean, with it. The rising temperatures and pressures make those carbonates chemically unstable, popping out the carbon and forging diamonds.

There are probably dozens of other ways to make diamonds, too. But no matter the process involved, they are usually primordial. The vast majority of diamonds are more than a billion years old. "The oldest we've analysed are like 3.5 billion [years old]," says Steve Shirey, a geochemist at the Carnegie Institution for Science in Washington DC.

Diamonds are survivors, capable of withstanding almost anything. This makes them deep Earth historians. Flecks of minerals and fluids known as inclusions that date from billions of years ago are imprisoned inside them when they form, preserving chemical records of what the primeval Earth was like. Thanks to this, we know, for example, that "the mantle has at least another ocean's worth of water" scattered within it, says Yana Fedortchouk, an experimental petrologist at Dalhousie University in Halifax, Canada.

The only way diamonds see daylight is by riding along on a very strange sort of volcanic eruption. Until 1869, the gems were only recovered from sediments left behind by rivers. But that year, they were found inside magmatic rocks at various South African farms, including some in Kimberley. These rocks were named kimberlites, and they are the product of extreme volcanic events.

To date, around 6000 kimberlite formations have been discovered. Most are in southern Africa, but they have been found on every continent, including Antarctica. About 3 per cent contain sizable diamonds. All of them have volcanic origins. And compared with the classic sort of mountainous volcanoes, kimberlite volcanoes are extremely weird.

Frothy missiles

The first feature that sets them apart is their magma. In most volcanoes, bubbling molten rock is left to simmer within Earth's crust, where it transforms into the complex lavas that erupt on Earth today. But kimberlite volcanoes skip that step. Their magma contains fluids and minerals – and even chunks of semi-intact rock – from deep within the mantle. "Kimberlites erupt deeper portions of Earth's mantle, and they erupt more of it as well," says Graham Pearson, a geochemist at the University of Alberta in Canada.

This means that kimberlite eruptions must happen quickly. As it ascends from the mantle into the crust, the carbon in the erupting material transforms into carbon dioxide gas, turning the magmas into a frothy missile. This is like "a rocket going off", says Janine Kavanagh, a volcanologist at the University of Liverpool, UK. As the magma accelerates, it carries up diamonds and entire pieces of mantle rock. "You have stuff that is coming up supersonically, and at some point ›

"You have stuff that is coming up supersonically, and at some point in the upper crust – kaboom"

ALEKSEY SUVOROV/ALAMY

The Mir mine is a kimberlite diamond quarry in Mirny, eastern Russia

in the upper crust – kaboom," says Andrea Giuliani, a kimberlite researcher at ETH Zurich in Switzerland.

Nobody has ever witnessed a kimberlite eruption, so geologists piece details together to come up with potential scenarios. Maybe the scorching-hot magma encounters some cool water, triggering violent, steamy blasts. Perhaps the trapped gas within its molten matter angrily bubbles up. Either way, one explosion leads to another, then another, then another.

If the eruption breaches the surface, it would make a crater that expands while the magma channel widens. "You'd have pyroclastic flows, you'd have a big eruptive plume," says Kavanagh. Explosions over many hours open a wound that digs deeper and deeper into the surface. Eventually, you may get lava fountaining or oozing out. And when it is all over, you are left with a gaping crater, some splinters of solidified magma known as dikes, and a pipe extending into Earth's crust choked with shattered volcanic rock and other debris.

Now, millions of years after their eruptions, what remains of kimberlite volcanoes isn't mountains. In fact, their architecture is frequently subterranean. Their most prominent features are buried, vertical pipes of rock, sometimes several kilometres in length. These are thought to be the conduits that once furiously funnelled magma to the surface. Some are "more like champagne glasses, some look more like a carrot", says Giuliani.

But the most perplexing fact to geologists is that kimberlite volcanism seems to have completely shut down. They started to erupt about 2 billion years ago and reached a peak roughly 100 million years or so ago, when the dinosaurs ruled the world. For a long time, the youngest-known kimberlite was 30 million to 40 million years old. After that, they disappear from the geologic record.

Vanishing volcanoes

This bewitches and confounds scientists in equal measure. They have a hard enough time decoding the behaviours and triggers of actively erupting volcanoes. Understanding long-dead kimberlites is considerably more difficult—the volcanological equivalent of archaeology. And it doesn't help that the pipes they form are filled with a chaotic jumble of smashed-up evidence. "Most of the rocks are complete rubbish," says Giuliani. "You can't study them." Altogether, this means that "there's this whole debate over the driving cause of kimberlite magmatism", says Philip Janney, a geochemist at the University of Cape Town in South Africa.

In an attempt to solve these puzzles, geologists like Gernon have spent a lot of time in diamond mines. While those working in other branches of geology have places they can revisit time and time again for field work, kimberlites are frequently blasted apart by prospectors hoping to find diamonds. The evidence Gernon needs is "now either on someone's ring, or crushed up", he says.

This is why, over the years, he has often descended into various chasms carved out of the landscape by miners in both Botswana and South Africa. Sometimes, he was driven into them along expansive, spiralling roads. In more claustrophobic mines, "you get in this cage, and you're dropped down this lift shaft," says Gernon. On occasion, "there's loads of baboons running around", he says.

It was only after he had completed his PhD, in 2007, that Gernon glimpsed his first diamond. He was wandering through a mine hidden beneath a frozen lake in the remote Canadian Arctic. This time, he was shivering at temperatures of -50°C. The contrast with the African mines "was supremely strange", he says. Suddenly, the light from his torch glinted off something stuck in the wall. "It was this perfect little triangle. It was beautiful. And I knew exactly what it was," he says: a 10-carat diamond. "I got very attached to it!" He wasn't, of course, allowed to keep it.

But he wasn't there for the diamonds. Instead, Gernon and his colleagues have examined the non-diamond minerals and chemistry associated with kimberlites sufficiently over the past few decades to build up a picture of the behaviour and potential origins of these volcanic eruptions. What we know for certain is that they plumb the depths of the mantle, are ancient and are packed with various forms of carbon.

And then there was the most surprising finding. As more and more kimberlites were dated, it became apparent that the eruptions didn't happen continuously all over the world. "Kimberlites pulse through time," says Pearson. There was a spike in such eruptions around 500 million years ago. Then another 370 million years ago. Then another when the dinosaurs reigned supreme. But between these fiery episodes, kimberlite volcanism was uncommon.

The dates of these eruptive epochs seem strange, at first. But geologists saw order in this chaos: kimberlitic fireworks coincide with the breakup of continents, including supercontinents, like Pangaea, atop which the dinosaurs roamed. Perhaps, some thought, the wounds that open as continents fragment could have created pathways through Earth's innards for the kimberlites to exploit.

There was just one problem. Almost all

kimberlites are found within cratons, the colossal, 200-kilometre-thick cores of continents, which don't experience such rifts. Cratons are several billion years old. Even when supercontinents are broken, these cores remain intact. That meant kimberlite magmas picked the thickest, toughest parts of the continents to puncture through – the path of most resistance – something most eruptive activity tends to avoid.

Chain reaction

This seemed impossible to explain – until last year, when Gernon and his colleagues had an epiphany that tied everything together. While comparing the emergence of kimberlites with the timing of various continental fragmentations, the team realised that kimberlite eruptions don't happen immediately after rifts first appear; most erupt about 26 million years later. And while some explode near the continent's new schisms, the majority emerge within the thick continental interiors.

Gernon and his team plugged these ideas into a computer simulation of Earth's tectonic plates, one advanced enough to authentically recreate how the shifting plates stir tides in the mantle below. As they watched, an elegant cascade took place. Their results explain where kimberlites get the carbon that allows them to erupt so furiously from and – crucially – how and why they break through the cratons.

"When you stretch the continent, you create this space, and all the hot stuff gushes up to fill this space," says Gernon. That upwelling causes swirling tempests of fluid in the lower, more malleable part of the mantle. That first tempest, below the rifting site, creates another instability next to it, then another, and another, starting to weaken the tough craton. "It's like a chain reaction," says Gernon. "That's when we knew we were onto something."

These maelstroms erode the continent's rocky underbelly, carrying off some of its water-soaked rocks. The base of the continent's interior happens to have an abundance of carbon-rich rocks. And here, at such great depths in the mantle, the extremely high-pressure environment cooks them in just the right way to produce that first carbon-rich batch of kimberlite magmas.

When enough batches of this are made, they rocket up through the chewed-up continental core, creating a dazzling array of kimberlite eruptions roughly 26 million years after the continent began to be torn apart.

Gernon doesn't like to call this work his "eureka" moment. But there is perhaps no better way to sum up his team's paper, published in *Nature* last year, which independent scientists enthusiastically received. "I think that goes as far as anybody to provide a universal picture [on the origins of kimberlites]," says Russell.

But the story may not end there. For a long time, the youngest known kimberlite was about 30 million years old. But in 2012, scientists were poking around in a series of shattered volcanic rocks and small cones in Tanzania, comprising three eruptive sites known as the Igwisi Hills volcanoes. Nobody had burrowed below the surface or peered into the crust using ground-penetrating seismic waves. But when they did, they found that the chemistry of the lavas here were unmistakably kimberlitic. And some of the volcanic rocks were dated to just 10,000 years ago or so.

Suddenly, Igwisi Hills became the youngest kimberlite volcanoes on Earth – shockingly young, born in the geologic equivalent of yesterday. This baffled researchers, since the world, right now, is tectonically calm. We aren't in a period of supercontinental annihilation.

But this revelation gels with the origin story of kimberlites as told by Gernon's team. Tanzania sits on a craton, and it is also influenced by the East African Rift, a massive rupture between two divorcing tectonic plates that began 25 million years ago. What this means is that the Igwisi Hills volcanoes could represent the prelude to a new era of kimberlite volcanism in this region. "It seems a good test of the model," says Gernon, smiling.

Perhaps, one day, someone walking along the shores of East Africa will see a fountain of fire erupt far inland, illuminating the night sky. Diamonds, trapped for billions of years deep below, will scatter across the landscape. And scientists will watch in awe, wondering what new secrets the planet has decided to unearth. ▮

Most kimberlite volcanoes are mines for diamonds (left). This 0.55-carat diamond (below) was found in a kimberlite in South Africa

LOWER: BJORN WYLEZICH/ALAMY; UPPER: REUTERS/SIMON AKAM

Robin George Andrews is a freelance science writer and author of *Super Volcanoes: What they reveal about Earth and the worlds beyond*

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Mathematics of life

Hey presto, it's a sum!

There are no rabbits pulled out of hats here, but these mathematical magic tricks will never fail you, says **Peter Rowlett**

Peter Rowlett is a mathematics lecturer, podcaster and author based at Sheffield Hallam University, UK. Follow him on X @peterrowlett

LOOK, I've got nothing up my sleeves. There are magic tricks that work by sleight of hand, relying on the skill of the performer and a little psychology. Then there are so-called self-working magic tricks, which are guaranteed to work by mathematical principles.

For example, say I ask you to write down a four-digit number and show me. I will write a prediction but keep it secret. Write another four-digit number and show me, then I will write one and show you. Now, sum the three visible numbers and you may be surprised to find the answer matches the prediction I made when I had only seen one number!

The trick is that while the number I wrote and showed you appeared random, I was actually choosing digits that make 9 when added to the digits of your second number. So if you wrote 3295, I would write 6704. This means the two numbers written after I made my prediction sum to 9999. So, my prediction was just your original number plus 9999. This is the same as adding 10,000 and subtracting 1, so I simply wrote a 1 to the left of your number and decreased the last digit by 1. If you wrote 2864, I would write 12863 as my prediction.

Another maths trick involves a series of cards with numbers on them (pictured). Someone thinks of a number and tells you which of the cards their number appears on. Quick as a flash, you tell them their number. You haven't memorised anything; the trick works using binary numbers.

KATIE STECKLES

Regular numbers can be thought of as a series of columns containing digits, with each being 10 times the previous. So the right-most digit is the ones, to its left is the tens, then the hundreds, and so on. Binary numbers also use columns, but with each being worth two times the one to its right. So 01101 means zero sixteens, one eight, one four, zero twos and one one: 8+4+1=13.

Each card in this trick represents one of the columns in a binary number, moving from right to left: card 0 is the ones column, card 1 is the twos column, etc. Numbers appear on a card if their binary equivalent has a 1 in that place, and are omitted if it has a 0 there. For instance, the number 25 is 11001 in binary, so it is on cards 0, 3 and 4.

You can work this trick by taking the cards the person's number appears on and converting them to their binary columns. From there, you can figure out the binary number and convert it to its regular number. But here's a simple shortcut: the binary column represented by each card is the first number on the card, so you can just add the first number that appears on the cards the person names. So, for cards 0 and 2, you would add 1 and 4 to get 5.

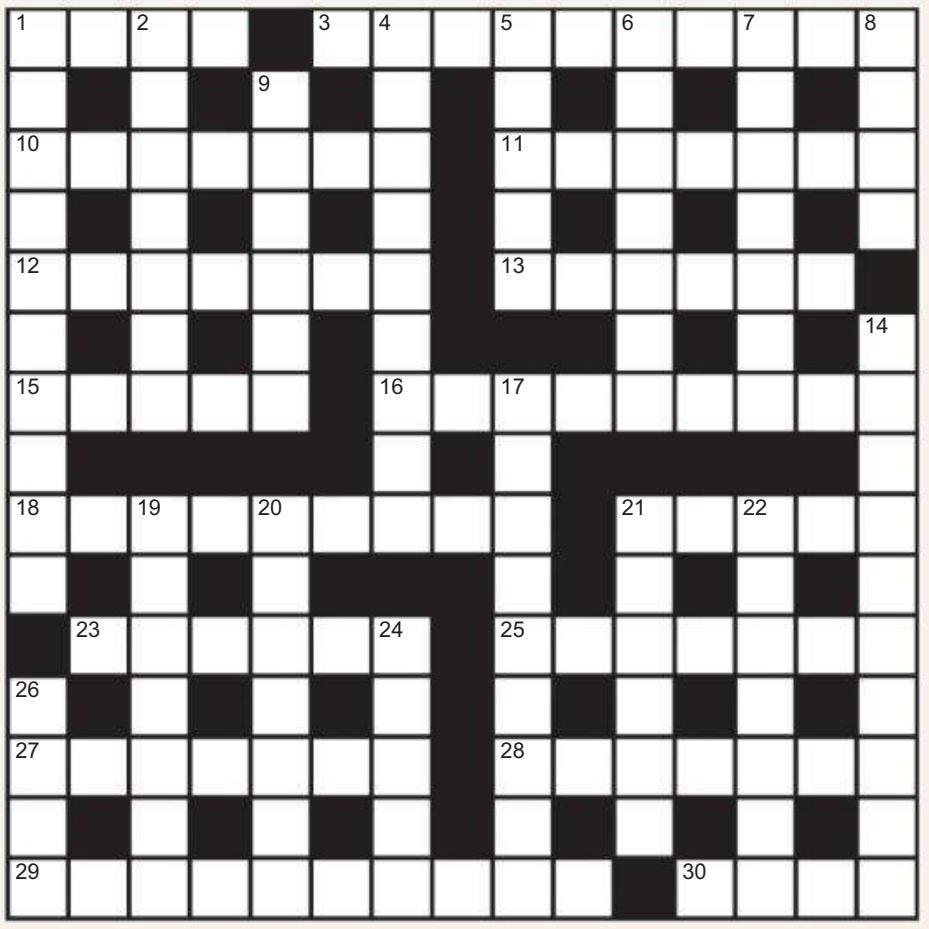
Many self-working tricks embed mathematical principles in card magic, memorisation tricks or mind-reading displays, making the maths harder to spot. The key is they work every time. ▮

These articles are posted each week at newscientist.com/maker

Mathematics of life reveals the mathematical ideas and shortcuts behind everyday situations. It appears monthly

Next week
Debunking gardening myths

Quick crossword #154 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Transfer of energy through the application of a force (4)
3 A, B, O or AB (5,5)
10 Observing (7)
11 Having or consisting of two modes (7)
12 Scientist's outerwear, possibly (3,4)
13 Prickly; challenging (6)
15 Vertices (5)
16 Reflexive repetition of speech (9)
18 1999 sci-fi action film starring Keanu Reeves (3,6)
21 In a state of elevated emotion or sensitivity (5)
23 Fish-eating raptor (6)
25 Corkscrew-shaped (7)
27 Flat highland area (7)
28 Made from metal moulded under high pressure (3-4)
29 Coded message (10)
30 Ursine mammal (4)

DOWN

1 Measurement, lambda (10)
2 Wetland habitat of dense rushes (4,3)
4 9,460,730,472,580.8 km (5,4)
5 Path of a satellite (5)
6 Parulis (7)
7 First, second or third, say (7)
8 Appendage of a spider or scorpion (4)
9 Fulcrums (6)
14 Device for solving arithmetic problems (10)
17 Cubes and cuboids, for example (9)
19 MDMA (7)
20 Opening such as a flue or window (3,4)
21 Mould-like fungus (6)
22 Blink (7)
24 Offspring; youthful (5)
26 Technical detail (informal) (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #244
set by Bethan Ackerley

1 What is the world's largest living snail species?

2 Which figure from Greek mythology lends their name to the element with atomic number 73?

3 What name is given to the stages that immature arthropods go through between moults?

4 Galantamine is used in treating symptoms of which condition?

5 What was the first artificial nuclear reactor?

Answers on page 47

BrainTwister
set by Mary Ellis
#12 Factorial factory

Mathematicians write 9! to represent the number "9 factorial", which means 9 × 8 × 7 × 6 × 5 × 4 × 3 × 2 × 1 = 362,880.

How many zeros will 10! end with?

How many zeros will 25! have at the end? (Careful, the answer isn't five.)

How many zeros will 1066! finish with?

Solution next week

Going naked

Why aren't humans covered in hair like other primates are?

David Muir
Edinburgh, UK
Under specific environmental conditions, natural selection picks the winners and losers. The winners' genes are passed to future generations and the losers' genes are lost to time. If the environment changes, what was previously a genetic disadvantage may quickly become a distinct advantage, and vice versa.

Other primates have hair that helps their thermoregulation, keeping them warm when temperatures drop. When their environment heats up, they don't need to move around much, as they mainly eat plant foods that don't run away.

When our hominin ancestors came out of the woods and chased animal prey on the savannah, they would have overheated when running long distances if they had been covered in fur. The savannah

"When our ancestors chased animal prey on the savannah, they would have overheated if they had been covered in fur"

hypothesis, also called the body-cooling hypothesis, is one view as to why our ancestors lost their thick, hairy coats. This thermoregulatory driver for fur loss, plus an increase in our cooling sweat glands compared with other primates, allowed our hominin antecedents to hunt on hot grasslands without overheating. For them, on an evolutionary timescale, it was a case of hair today, gone tomorrow.

Trevor Campbell
Berrima, Australia
Hair is metabolically expensive to produce and, like any expensive attribute that isn't needed, will gradually be lost as a function of normal evolution. Think of animals in caves, which are often lacking in pigment and/or blind.

Humans don't need much hair because, somewhere in our past, we learned to steal it from other animals and wear their pelts as clothes when required. Later, we learned to use other materials, such as plant fibres. These options are cheaper, from an energy point of view, than growing your own.

Of course, all ideas about how evolution progressed are just speculation, as rerunning the experiment isn't possible, and so should be taken with a large pinch of salt.

Marc Verhaegen
Putte, Belgium
One possible answer could be the hypothesis of our semi-aquatic evolution, which I have written about. There is zero doubt that at least our early Pleistocene ancestors frequently waded bipedally in shallow water and regularly dived for shellfish.

Only a lifestyle including the collection of shallow-water foods – which also makes sense of why we lost our fur – can explain why our ancestor *Homo erectus* evolved pachyosteosclerotic skeletons (with very thick and dense bones, which are exclusively seen in shallow-diving tetrapods).

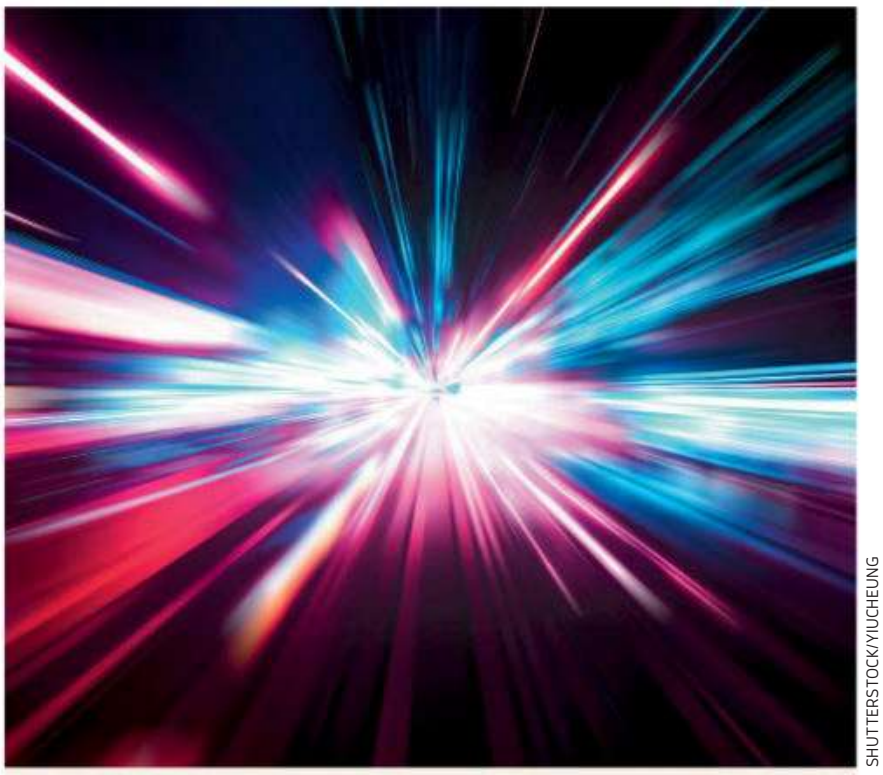
A semi-aquatic lifestyle also explains why some hominins had skulls with auditory exostoses, bony outgrowths in the ear canal that are typically caused by chronic colder-water irrigation. And it accounts for why they had descendants who colonised islands far overseas like Flores; evolved brains twice as large as those of great apes and australopiths, facilitated by DHA and other brain-specific nutrients found in seafood; and frequently used stone tools with their very dexterous hands, comparable to sea otters opening shellfish.

Bernard Harper
Liverpool, UK
This question was answered in *New Scientist* by marine biologist Alistair Hardy in 1960. Your magazine has covered many ideas about our "unique" naked skin. But only one has grown without scientific rebuttal and explains new findings. For five decades, Hardy's insight was expanded by the late Elaine Morgan, author of books including *The Aquatic Ape*, and often featured here. She showed that nakedness and other human traits are most elegantly explained by aquatic adaptation. She predicted that many new aquatic-human commonalities would be found, as was eventually shown.

This Last Word question appeared in the same edition as your article on the menopause, which, while once thought to be "uniquely human", has been shown to be common in orcas and other whale relatives.

Morgan would have also been delighted to discover that vernix caseosa, the waxy biofilm found on newborn babies, is also found on the naked skin of newborn seals. This covering seems to be an adaptation to being born near or in water. Combined with our subcutaneous fat layer (essentially blubber), relatively bare skin is necessary because our ancestors foraged in rivers, lakes and coastal waters that most primates regard as an existential threat.

This counterintuitive idea is like continental drift: an often ridiculed concept that, half a century later, became plate tectonics. But who's laughing now?



SHUTTERSTOCK/YUCHEUNG

This week's new questions

Pedal to the metal **We know the maximum possible speed is that of light in a vacuum. But is there a maximum possible acceleration too?** ***John Corey****, Melrose, New York, US*

Is there a maximum possible speed of acceleration, like there is a highest possible speed?

Buzzing off **How come, when the front door of my house is open, a fly can enter my home easily, but not escape as easily out of the same door?** ***David Gibson****, Ashburton, New Zealand*

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Questions should be about everyday science phenomena
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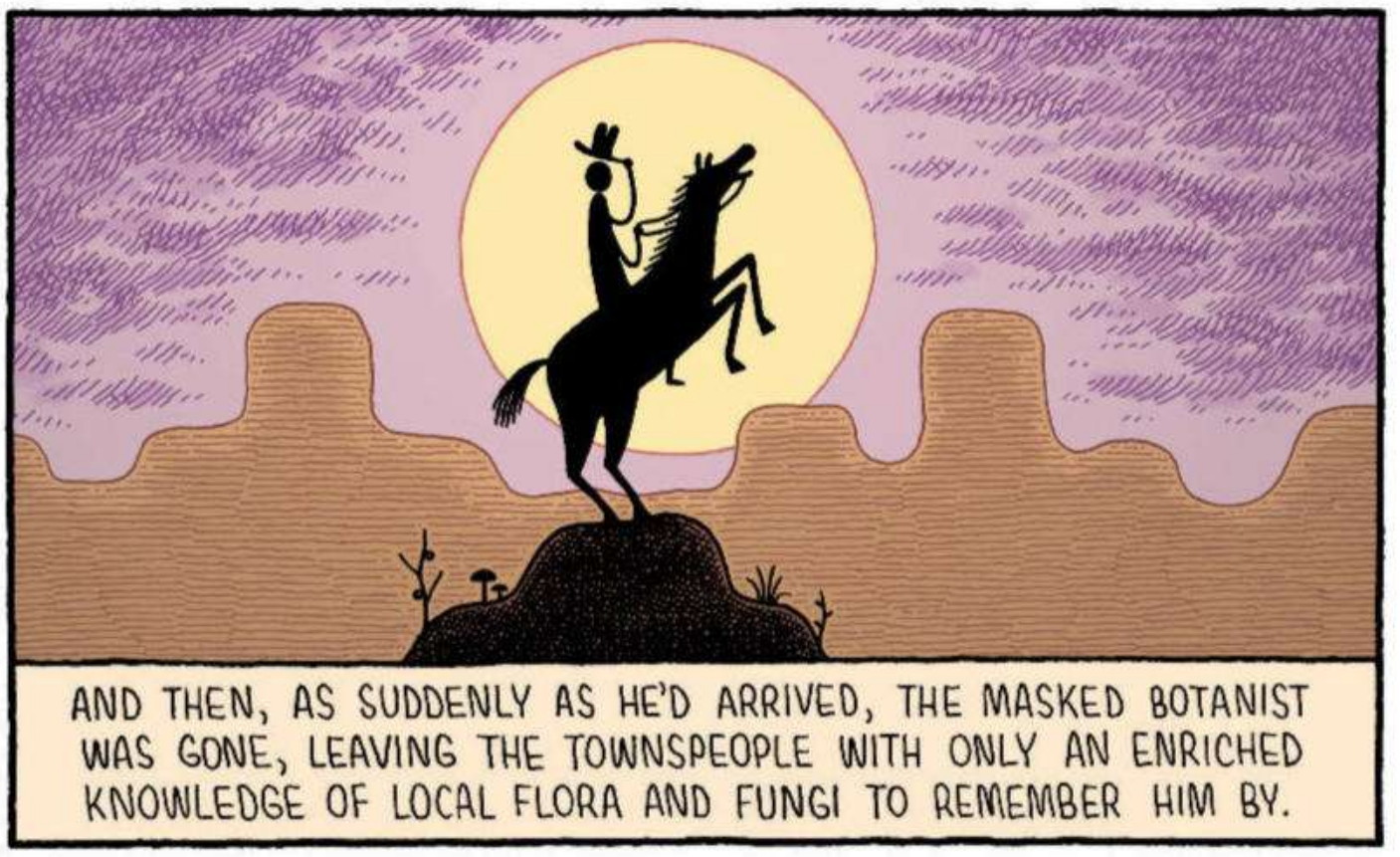
Tom Gauld
for New Scientist


AND THEN, AS SUDDENLY AS HE'D ARRIVED, THE MASKED BOTANIST WAS GONE, LEAVING THE TOWNSPEOPLE WITH ONLY AN ENRICHED KNOWLEDGE OF LOCAL FLORA AND FUNGI TO REMEMBER HIM BY.

Snap, crackle, pop

How can popped knuckles be so exceptionally loud? (continued)

Marthinus Roos
Elgin, Moray, UK
The surfaces of human joints fit against each other very well and have rims of synovium, the membrane lining of the joint. Together, these form a very effective suction cup, which work together with the surrounding ligaments and thickening in the fibrous "sacks" around the joints, known as joint capsules, to hold the bones of the joint in the correct place and orientation.

When a distraction force (such as pulling on a finger) is applied, the ambient pressure in the surrounding tissues, which is equal to the air pressure surrounding the body, keeps the joint surfaces together until the force is big enough to overcome this. A vacuum is then suddenly formed in the joint space when the bones pull apart as far as the ligaments and capsule allow.

"Cracking knuckles is harmless to the joints, although I can't vouch for its effect on personal relationships"

The sound is produced when the surfaces part at speed. This is known as a vacuum snap. There is no bubble formation involved (a vacuum isn't a bubble).

In my career as an orthopaedic surgeon, I have never seen a patient with problems in their knuckle joints that could be ascribed to them cracking their knuckles. Therefore I deduce that the habit is harmless to the joints, although I can't vouch for its effect on the person's relationships.

Tempus fugit

Why do older people seem to experience time passing more quickly? (continued)

Name and address supplied
We all know that children are very active. To a 7-year-old, an hour is an eternity, whereas to a 70-plus-year-old like me, it is just time for a sit down.

But my brother has bipolar disorder and it is very clear to me that his condition hugely affects his perception of the passage of time. When he is "up", he acts like a teenager; when he is "down", he is like an old man. The most extreme example I can quote is when he was staying in our not-quite-completed house 10 years ago and said – 45 minutes before church – "surely that's enough time to paint the hallway".

In other words, it isn't just a matter of time passed – mental state also comes into the picture.

Graham Birch
Winterborne Stickland, Dorset, UK
When I am doing Dry January, time seems to slow right down, especially in the evening. Also, when I am lying in bed after the alarm has gone off in the morning and I need to go to work, time speeds up, notwithstanding the slowdown of Dry January. ▮

Answers

Quick quiz #244 *Answers*

1 The Australian trumpet (*Syrinx aruanus*)
2 Tantalus (also known as Atys) – the element is called tantalum
3 Instars
4 Alzheimer's disease
5 Chicago Pile-1

Cryptic crossword #131 *Answers*

ACROSS 1 Drew in, **4** Tonsil, **9** Nebulae, **10** Rumen, **11** Sewer, **12** Arsenic, **13** Pondicherry, **18** Sub-zero, **20** Hobby, **22** Botox, **23** Incense, **24** Relent, **25** Fly off

DOWN 1 Danish, **2** Elbow, **3** Ill-bred, **5** Orris, **6** Seminar, **7** Lunacy, **8** Melancholia, **14** Orbital, **15** Ethical, **16** Isobar, **17** Myself, **19** Exxon, **21** Banjo

#11 Club shuffling *Solution*

If the players are A, B, C and D then the possible games are: AB vs CD, AC vs BD and AD vs BC. So there are three games in total.

If A wins all their games then all the left-hand teams are winners, so B, C and D each win once and lose twice. If A loses all their games, the reverse is true: B, C and D each win twice and lose once.

If there are two teams of three players, a similar process shows that there will be 10 games altogether. If one person wins all their games then each other player will win four. If one person loses all their games then each other person will win six.

Wins for kids

Spectator sports are good for children – good for creating children, that is – according to data in a study by Gwinyai Masukume at University College Dublin, Ireland, and his colleagues.

That data pertains to major American football, Association football (soccer) and rugby union tournaments in Africa, Asia, Europe and North America.

"With a few exceptions," say the researchers, these popular contests "were associated with increases in the number of babies born and/or in the birth sex ratio 9(±1) months following notable team wins and/or hosting the tournament".

Sports events on this level seem to work that way for winners – but not for losers, says the study, which was published in the journal *PeerJ*. The downside is, no kidding, substantial: "unexpected losses by teams from a premier soccer league were associated with a decline in births 9 months on".

Celebratory sex

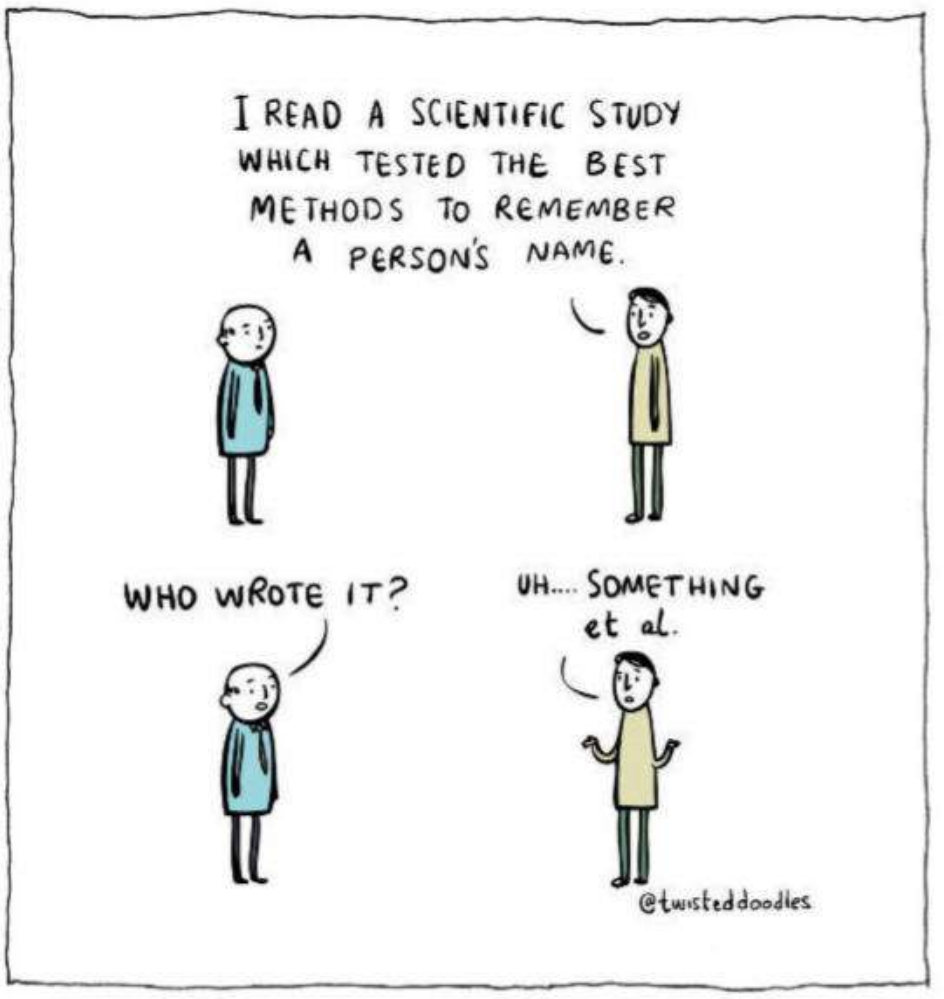
That spectator-sports study begins with a seductive sentence: "Major sporting tournaments may be associated with increased birth rates 9 months afterwards, possibly due to celebratory sex."

Not many researchers focus on the topic of celebratory sex. But four scholars at the University of South Dakota did, in a 2017 paper called "Sexual behavior in parked cars reported by Midwestern college men and women".

The foursome write candidly about their observations: "[Some people] would plan ahead for days or weeks for a leisurely, lengthy parking session of 'celebratory' sex for birthdays, holidays, graduations, proms, or 'breaking in' a new car... sex while parked was primarily a positive sexual and romantic experience for both men and women."

The study's abstract climaxes with a simple thought: "The future study of sex in parked cars in urban environments is recommended."

Twisteddoodles *for New Scientist*


I READ A SCIENTIFIC STUDY WHICH TESTED THE BEST METHODS TO REMEMBER A PERSON'S NAME.
WHO WROTE IT?
UH.... SOMETHING et al.
@twisteddoodles

Got a story for Feedback?

Send it to feedback@newscientist.com
or New Scientist, 9 Derry Street, London, W8 5HY
Consideration of items sent in the post will be delayed

Timeliness of time

The eternal question "What is time?" has staggered doubly to centre stage – first in a Finnish report about Russian time zones, second in a shifty action by the nation of Kazakhstan.

Nelli Piattoeva and Nadezhda Vasileva at Tampere University in Finland wrote a 20-page assessment called "Taming the time zone: National large-scale assessments as instruments of time in the Russian Federation".

Russia has 11 time zones. Piattoeva and Vasileva instruct us that: "The presence of multiple time zones evidences the lack of a unified spatio-temporality." And they express a thought that no one has ever quite put into clear words: "Bureaucratically, the desire for simultaneity and synchronicity takes the form of a meticulous ordering of a sequence of actions through prescriptive documentation." They reveal that there is a hinge to everything: "In our analysis, we reverted repeatedly to the most difficult question of all: what is time?"

Independently, the government of Kazakhstan added clarification, wonder and, maybe, confusion to the general timely mix. On 1 March, Kazakhstan rendered its two time zones down into a solitary, nationwide time zone.

The Times of Central Asia reported, two weeks prior to the big day, that "not all citizens are happy about it, with some arguing it will impact their health". *The Times* interviewed Sultan Tuleukhanov at Al-Farabi Kazakh National University, who warned: "There is such a concept as desynchronises, a type of inconsistency. In particular, it's a change to the chrono-structural parameters of biological rhythms of the human organism."

Feedback salutes the boldness, if nothing else, of anyone who dares monkey with the chrono-structural parameters of biological rhythms of the human organism.

Unread, un-existent

How many research studies that nobody had read... eventually just disappeared? And how many studies that have disappeared... had never been read by anybody, even before disappearing? Rough answers to both questions – they are not quite the same question! – now exist.

The first question got addressed almost two decades ago, when Lokman I. Meho at Indiana University Bloomington published a paper (which hasn't yet disappeared) called "The rise and rise of citation analysis".

Meho wrote: "It is a sobering fact that some 90% of papers that have been published in academic journals are never cited. Indeed, as many as 50% of papers are never read by anyone other than their authors, referees and journal editors."

The second question got a good going-over by Martin Paul Eve at Birkbeck, University of London. His new study (which also hasn't yet disappeared) is called "Digital scholarly journals are poorly preserved: A study of 7 million articles". The study did an "appraisal" of 7,438,037 scholarly citations that have unique identification codes called DOIs. Well, the study attempted to do an appraisal. Eve reports that 2,056,492 (27.64 per cent) of those items appear to be missing.

Eve also says that 32.9 per cent of the organisations responsible for digitally preserving documents "seem not to have any adequate digital preservation in place".

Feedback celebrates and laments that this deepens the meaning of an old ideal: that research should raise more questions than it answers. ▮

Marc Abrahams

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They are researchers, entrepreneurs, and conservationists. Their projects use innovative strategies to protect ecosystems, save endangered species and improve human well-being. Rolex is working towards a sustainable future for our planet by supporting the efforts of these pioneers.

Constantino Aucca Chutas. This Peruvian biologist has been planting millions of trees in five South American countries. He works with local associations to restore the high Andean forests. **Denica Riadini-Flesch.** This Indonesian economist founded a clothing company that supports sustainable clothing production while improving women's economic and social conditions in rural areas. **Inza Koné.** A pioneer primate conservation biologist in Africa, this Ivorian researcher is committed to involving local communities in preserving one of the last wild areas in West Africa, home to endangered large mammals. **Beth Koigi.** This Kenyan entrepreneur is working on a system that produces water from air borne moisture to supply drinking water to populations living in arid or semi-arid regions of Kenya. **Liu Shaochuang.** This Chinese remote sensing specialist is studying the habitat and movements of the last wild camels in the Gobi Desert to protect this unique species from extinction.

The Rolex Awards for Enterprise, launched in 1976, are part of Rolex's Perpetual Planet Initiative. They aim to support people all around the world who are working towards a sustainable future.

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